The Iowa engineer

Iowa State College

THE IOWA ENGINEER

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CONTENTS

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THE IOWA ENGINEER

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Handling Rock and Waste in Iowa Coal Mines

F. F. JORGENSEN*

The original method of handling rock and waste at the coal mines was to gob it in abandoned rooms and entries. Practically all this work was done on night shift, and needless to say this was an expensive method. However, the expense was not the only bad feature of this practice. Many gob fires were caused because this refuse contained much fine coal. In handling the dirt this way it was often necessary to haul it long distances. Trips of loaded cars were frequently in the way and had to be switched, usually one car at a time. And sometimes more than one trip had to be switched before the track was clear for hauling dirt. This much "dead" work was done. A dirt crew usually consisted of two loaders, one unloader, and one mule driver with his mule. The average capacity of this crew was twenty pit cars per shift of eight hours. Under favorable conditions this average was somewhat higher, but night crews usually find conditions unfavorable.

The next step was to send the cars loaded with rock and dirt out to the shaft on the day shift with the regular trips of coal, and hoist to the surface. These cars were taken off the cage onto a trestle on the opposite side of tipple from the coal chute. They were then shoved out to the end of the trestle and dumped by hand. A switch was placed close to the tipple so that an empty car could be put on the cage to replace the load just taken off. This method, of course, had several advantages over the old one. The cost of unloading below was eliminated, and

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gob fires were lessened to a certain extent. Much of the loading could be done on the day shift by the miners at the contract price per car. From then on until the car of rock was taken off at the trestle the cost of handling was the same per car as for handling a car of coal over the same distance.

Though this was an improvement over the old method still there were several serious objections to it. Two or three strong men were required to handle the cars and dump them. But the chief objection was the time lost in taking the loaded car off the cage and replacing it with an empty. Where the Olsen self-dumping cages were used, four dumps of coal were lost on every car of rock or waste hoisted. This item of lost time be-

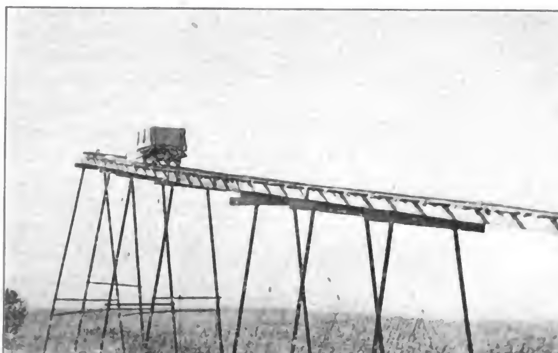


Fig. I. Inclined Track at Mine No. 16

came quite serious when there were anywhere from fifty to one hundred cars of refuse to be hoisted per day. It became imperative to devise some way of dumping rock at the same rate as coal, or go back to the original way of storing it in the abandoned working places.

After much thought, and some experimenting, a trap door was designed to be placed in the upper end of the coal chute. A set of compound levers with counterweights was connected to the shaft on which this trap door was hinged. A hand lever

Fig. II. Dump at Mine No. 16

was placed within easy reach of the check puller, so that he could raise the door when he received the signal that a car of refuse was being hoisted. Immediately below the trap door a side chute was built to receive the rock.

When the check puller receives the signal that rock is being hoisted, he raises the trap door and the rock is dumped into the side chute at the same rate that coal is dumped down the main chute. The side chute extends at a forty per cent grade to within six feet of the ground. At the bottom end is a heavy door that is raised by means of a long lever. This door travels up and down between guides made of small angle iron fastened to the side of the chute. When a car of rock has been dumped into the chute, the door at the lower end is raised and the rock is deliveded directly into a self dumping car that has a capacity of three ordinary pit cars. Two cars however is usually taken as a load. The track on which the self dumping car runs is built on an incline of thirty per cent.

Fig. No. 1 shows the inclined track at Mine No. 16, just after it had been completed and the car is making the first trip.

The car is pulled up the inclined track by a 7-8 inch haulage

rope attached to a small drum which is operated by a 50 H. P. motor.

The drum is 18 inches in diameter and 3 feet 0 inches long. The motor is a series wound gathering motor taken from the mines. The running wheels are removed, and the frame set upon a concrete foundation. To provide a drum shaft, an axle shaft was removed from the motor and was replaced by a shaft just twice the length of the axle shaft. One half of this shaft was an extra duplicate of the axle shaft, and the other half was a straight shaft to hold the drum. A heavy bearing was placed at the outer end of this drum shaft.

The rope is 7-8 inch crucible steel, 6 strand, 19 wire, long lay haulage rope manufactured by the John A. Roebling Sons' Company.

Full rope speed when the car is loaded is 650 feet per minute. Empty car returns at 1000 feet per minute, maximum speed. The power consumed in pulling loaded car up the incline is 200 amperes at 250 volts. This is 33 1-3 per cent over load on the motor, but it is the Goodman heavy duty type and will stand heavy overloading without injury. The time required for a round trip of 250 feet is 3-4 minute. With this arrangement one man handles all the rock and waste that is hosted and has time to help with other top work.

At first the cost of maintenance on this type of rock handling plant is comparatively high. The reason for this is that frequent extensions of the incline track must be made as the waste pile grows and fills up to the track. It requires patience and perseverence to maintain this track and make the extensions after the waste pile begins to burn. The legs of the bents supporting the trestle soon burn off no matter whether these legs are made of heavy angle iron, pipe, or railroad iron. When this happens temporary bents must be placed on top of the burning pile. Since the pile is continually settling as long as it burns the track must be raised and lined up frequently, and temporary bents placed wherever necessary.

Fig. 2 shows the dump at Mine No. 16 six months after it was put in service. It gives a good idea of how the track settles, and also of the position in which it is necessary to place some of the

temporary bents while the waste pile is burning. It also requires close watching to prevent the wood work from burning. Much of the trouble is ended, however, when the first fire burns itself out. This requires from five to eight months. By this time the waste pile has grown so that a track extension of eight feet will last about two months. Also, since the first and worst fire has burned out, the track may now be raised up to a grade and lined up permanently, with little danger of further settling.

As the waste pile grows in age and size, the cost of upkeep on this type of waste handling plant grows less and less. (Occasionally the self dumping car jumps the track, and rolls down the side of the pile, but the cars are built very substantially of I beams, angles and two inch plank, so little damage is done. The car is pulled around to the foot of the incline, placed on the track, and business resumed with a loss of about two hours time. Sometimes the haulage rope breaks, and the loaded car comes back down the track. If it keeps to the rails it bumps into heavy oak posts set at the foot of the incline. One particular car has had this happen twice, and with the exception of a broken plank, or two, little damage was done either time.

The complete cost of trap doors, chute, car, inclined track to height of 30 feet, drum and foundation for motor is $500.00. This does not include cost of motor.

This type of dirt handling plant is used at our mines No. 15, 16 and 17, and has given excellent service.

At mines No. 12 and 14 the aerial tramway type of rock handling plant is used. Two 1 1-4 inch cables stretched between two towers are used to support the cars. Thus far we have used nothing but discarded hoisting cable spliced together for required length. The outer tower, 75 feet high, is set from 400 to 500 feet away from the tipple, and the other tower, 30 feet high, is set directly alongside the tipple. Heavy concrete piers are set back from each tower and the two cables are securely anchored in these. Heavy turn buckles with 3 foot take-up are provided at each end of the cable for taking up the slack. A car having the capacity of three ordinary pit cars is used. This car is swung between the two cables, and is provided with a self dumping device.

Fig. No. 3. shows tramway at Mine No. 14.

The pulling rope is 3-4 inch diameter, 6 strand, 19 wire long lay haulage rope manufactured by John A. Roebling Son's Company. This pulling rope is wound four times about a grooved drum and idler both of which are 18 inches in diameter. One end of the rope passes from the drum and idler over a sheave near the top end of the inner tower, and is then fastened to the rear end of the car. The other end of the rope passes over another sheave, also near the top of the inner tower; then passes beneath the car to a sheave on top of the outer tower, then back to the fastening at the front end of the car. With this arrangement the car may be pulled in either direction with single rope.

Fig. No. 4 shows No. 14 tramway with car dumping and also shows the middle tower. This middle tower was placed on top of an old rock pile to support the cables. The sag in the ropes at this point was too great to allow the loaded car to pass over the old pile.

The motor used is the same as used in the first described plant. Maximum rope speed in either direction is 650 feet per minute. Power consumed is 150 amperes at 250 volts. The cost of plant

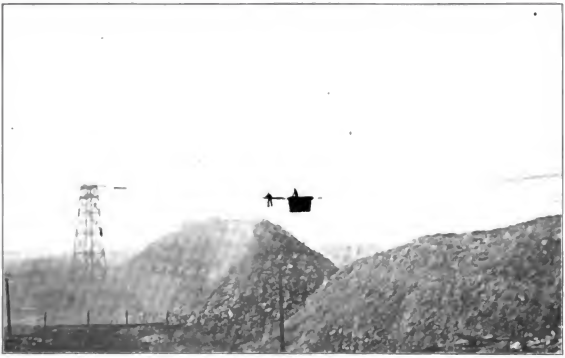


Fig. III. Tramway at Mine No. 14.

complete is practically the same as for the inclined track type.

The principal advantage of the Aerial type over the inclined track is that it has no inclined track to support over a burning waste pile. Therefore maintenance cost at first is much lower. Power consumption is also less.

There are several disadvantages however.

First, less capacity. The inclined track type has about one quarter greater capacity. This is because the car has much greater speed on the return trip.

Next, if for any reason the car gets off the ropes and falls to the ground, the rock handling plant is out of commission for at

Fig. IV. Car Dumping on Tramway

least a day. It is no small task to raise the car which weighs a ton, back onto the ropes.

Also, if for any reason it is necessary to stop this plant for a short time no rock can be hoisted from the mine till it is ready to operate again. This is because the side chute that delivers the rock and waste into the self dumping car is very short, therefore has no storage capacity. The other type of plant has a long side chute which has a storage capacity of 12 to 15 cars. This, of course, is a decided advantage for the plant may be shut down

for some little time and still cause no delay in hoisting the rock from the mine.

Last, but not least, where the dumping space of the Aerial tramway is filled the outer tower must be moved. The cost of doing this would pay for many months of incline track maintenance. Of course at a mine where no great quantities of waste have to be handled the outer tower would probably never have to be moved.

Taking everything into consideration, the inclined track type of rock and waste handling plant recommends itself for use at mines where large capacity and practically continuous service are required. And the Aerial tramway type recommends itself for use at mines where only a medium capacity is needed, and low power consumption a necessity.

A System of Industrial Education for Iowa

BY A. MARSTON*

(In two parts.)

PART I. THE GENERAL SITUATION.

IOWA'S NEED. "What's the matter with Iowa?" is a question which used to receive but the one response, "She's all right." Since the last census, however, this inquiry, which every resident of another state seems to feel bound to make whenever he encounters an Iowan, makes us all feel a little ashamed, and invariably starts us upon some long explanation which somehow, in spite of us, takes on an apologetic tone. We wouldn't mind that slight loss of only 7,082 people in ten years if only we could find some company, but to discover that our Iowa, with her boasted agricultural advantages and her intelligent population, is the only state in the Union to lose, or even stand still, during the last decade is enough to destroy all our confidence in our own former ideas as to Iowa's greatness.

*Reprint of an article in "Iowa Factories" May and June 1912, by Dean Marston of Iowa State College.

And this confidence is still more severely shaken when we find on further investigation that, as Professor John E. Brindley, of Ames, will show in his forthcoming bulletin of the Iowa Engineering Experiment Station on "Iowa Population as Related to Industrial Conditions," the rural districts of Iowa have lost about 115,000 population from 1900 to 1910. This is nearly 1,200 per county, or about 10 per cent in 10 years, and Iowa's rural population is no greater now than 30 years ago.

The fact is that Iowa has been giving, not too much, but too exclusive attention to agricultnre. The state has been as foolish as a man who, on account of his pride in one brawny arm, should leave the other strapped to his side and crippled for want of proper development. Not even Iowa can keep up its share of the work of modern civilization with the strong arm of manufactury industry withered and undeveloped.

In fact the movement of population partially away from rural districts is due to causes which are world wide, and which are acting in many other states as well as in Iowa, and which are about as resistless at the present time as the tremendous forces which govern the tides of the ocean. With the introduction of improved machinery and more scientific agriculture on the farms the number of people required to do the work is decreasing. Moreover farms are increasing in size because the large farm is more profitable than the small.

INDUSTRIAL DEVELOPMENT IOWA'S REMEDY. The careful and thoughtful investigator of Iowa conditions cannot avoid the conclusion that agriculture alone has failed in the past and will inevitably fail worse in the future to maintain and improve Iowa's standing among the great states. Had it not been for such development in manufacturing and mining industries as has already occurred Iowa's loss in population during the last decade would have been so great as to constitute a serious wound instead of a mere pin prick to our pride.

We must get out of our heads in Iowa, and out of the heads of capitalists in other states, the idea that we can have nothing but agriculture in Iowa. There are still hundreds of thousands of our own people who deride the idea that we can ever

develop great manufacturing industries, just as the churchmen of Galileo's time derided his idea that the earth moves. The great scientist was forced to recant for the moment, but under his breath he still maintained that "it does move." So the statistics given by Mr. Wrightman on page 11 of the February number of Iowa Factories show that manufacturing in Iowa "does move," in spite of skepticism, for the annual value of Iowa manufactured products was $325,000,000 in 1911, as compared with $450,000,000 from the fields. Moreover the value of manufactures increased 144 per cent from 1900 to 1911, and the value of field products only 23 per cent.

There is every reason to believe firmly that Iowa can, if she will, develop most extensively her manufacturing industries, which have already become so great in spite of absolute neglect.

The Iowa farmer will profit at least as much as anyone by our manufacturing development, for he now labors under a very great disadvantage in being exploited for the sake of long hauls for railways, and compelled both to buy and to sell in distant markets.

To serve the best interests of her people Iowa must develop symmetrically every side of that great quadrangle of material progress, agriculture, manufactures, commerce, mining.

INDUSTRIAL EDUCATION NECESSARY IN MODERN INDUSTRIAL DEVELOPMENT. Industrial development other than agricultural, then, is absolutely essential to Iowa, and is possible. Simply wishing for such development, however, will not give it to us. We must go to work, energetically, intelligently, and persistently, in order to attain the goal. There are many essentials to industrial development which Iowa must supply, and can if she will; of these none is more important than a good, working system of industrial education.

Under modern conditions the highest success cannot be attained in any industry without scientifically trained and educated employees. The days have gone by when a few years in the common schools and an apprenticeship under an employer gave all the training and education needed by an industrial workman. The wonderful advances in science and its applications to the industries, and the great changes in the

methods of conducting industries, have rendered a common school education insufficient, and have completely broken down the old apprenticeship system.

Hence both employers and labor are uniting in the demand for industrial education: The employer, because without the most scientifically trained labor he cannot secure such economy of production and such high grade of product as to enable him successfully to conduct a modern industry; labor, because the individual laborer cannot, without scientific industrial training, command the highest returns, or secure the highest skill, or get the most out of modern life.

Everywhere in the industries the demand for skilled workmen and foremen is strong and insistent. Iowa must supply the demand if she would extensively develop her industries.

INDUSTRIAL EDUCATION IN GERMANY. In the world's family of nations Germany has perhaps accomplished more than any other in overcoming great natural industrial disadvantages and attaining industrial leadership in spite of them. To use the language of the Wisconsin Commission to report on Industrial Education:

> "Germany started her present prosperity with poor resourses; her land was poor and for hundreds of years the country was devasted by wasting wars. The mineral resourses were slender, the people were not trained as are the English by ages of manufacturing and commercial effort. Germany was a country of peasantry. Yet by well directed effort she changed all this. Germany's present prosperity is based upon a purposeful effort to educate her people. Her economists recognized the fact that nothing could win in the end except the intelligence of of the individual man."

> Further, the Wisconsin Commission quotes as follows: FRANK VANDELIP- "I have become firmly convinced that the explanation of the remarkable German progress is to be traced in the most direct manner to the German system of education. The schoolmaster is the great corner-stone of Germany's great commercial and industrial progress. The school system of Germany bears a relation to the economic situation that is not met with any other country." Again, quoting SHADWELL,-"The (German) manufacturers give liberal support to the schools and further encourage them by giving employment to the graduates, and there is no doubt it pays them. A manufacturer in Elberfield was showing me one day a length of dress material. "That," he said, "is going to England and it is made of English stuff." I get the materials from England, manufacture them and send them back. I pay carriage both ways, and yet I can sell this in English markets." "How can you manage it?" I asked. "Well," he said, 'you see this is a nice design'. There is brains in it. It was a good answer, and I am inclined to believe it.

Very largely by means of her great system of industrial education, then, Germany has overcome industrial disadvantages greater than Iowa's, and attained rank among the first three great industrial and commercial nations of the world. Iowa may well profit by her example.

In studying the industrial schools of Germany it becomes apparent at once that it has not proved possible to solve the problem by central trade schools, serving whole states, or even large districts. It has been found necessary to put some form of industrial schools into every German village and community. Industrial education must be supplied to the boys and girls of 14 to 18 years of age, and these cannot and will not be sent far away from home to attend schools of any kind. Moreover, Germany has found it necessary to provide industrial education for tens of thousands of boys and workmen who can devote only part time to the schools, because they must labor at their trade for their daily support.

Germany's experience proves conclusively, then, that a successful system of industrial education must provide for an industrial school of some kind in every village and city, along side of the regular secondary schools. The same principle applies to trade education in agriculture, for farmers' boys.

The industrial schools of Germany, which have proven so successful under so many years of actual experiment and development, may be classed in two groups:

First, CONTINUATION SCHOOLS, and EVENING CLASSES, for the industrial training of boys and girls and older work people who are actually employed in the various industries, and can give only part time to the schools. Employers are required to grant the proper time for the work, which generally amounts to about one day per week, arranged as best suited to the work of each man.

The CONTINUATION SCHOOLS are of the utmost value, and benefit more people than any other kind of industrial school. The training in them includes both general business and trade subjects, and in many cases specific training in the special trades of the vicinity. The students work by set tasks or exercises rather than by classes, and the entire system is very adaptable to the varying needs of different communities, and to natural development into trade schools.

The EVENING CLASSES are simply makeshifts to help those improve who have failed to get sufficient education.

Second, TRADE SCHOOLS, for those who can devote full time to the schools. These naturally develop from the con-

tinuation schools in the various communities, and just such a trade school is developed in due course of time for each community as its own particular industries seem to demand.

COMPULSORY ATTENDANCE AT GERMAN INDUSTRIAL SCHOOLS. The Wisconsin Commission reports that the general rule in Germany is to require compulsory school attendance for a definite time, say one day per week, at continuation or other industrial schools between the ages of fourteen and sixteen, and sometimes to eighteen, (except, of course, in the case of students attending the ordinary secondary schools).

ADMINISTRATION OF GERMAN INDUSTRIAL SCHOOLS. The Wisconsin Commission reports that in Germany, as in other countries, experience has demonstrated that the universal tendency of the trade school is to get away from practical work, directly fitting the students for work in the industries, and toward a general training which does not meet the real industrial need.

To overcome this tendency Germany has found it necessary to place the administration of the industrial schools of the various communities in the hands of local administration boards corresponding to our school boards, but composed of business men, manufacturers, and workmen. In this way a very direct and practical relation is maintained between the industrial schools and the actual industries, in each community.

INDUSTRIAL EDUCATION IN THE UNITED STATES. As might be expected from the democratic nature of our institutions, no one general system of industrial education has been adopted or extensively tried in the United States. The urgent need for such education, however, and its increasing recognition in recent years have led many communities into more or less thorough experimentation with different plans, and much of interest and value has been developed.

MANUAL TRAINING. Manual training has been introduced into many elementary (or grade) schools and secondary (or high) schools. This work is of value in training the hand, as well as the intellect, but does not meet the industrial need by training men for specific industries.

TECHNICAL HIGH SCHOOLS AND INSTITUTES. A number of populous communities have erected and equipped technical high schools within recent years, and there are a number of privately endowed technical institutes in the larger cities. These schools are doing good work, but require watching to prevent their getting away from practical work, of direct value in the industries. They show a tendency to try to develop into engineering schools of inferior grade rather than real trade schools. Thus the Carnegie Technical Schools of Pittsburgh, Pa., are developing engineering courses on the same campus (!!) as the Western University of Pennsylvania.

EVENING CLASSES. These have been established in many cities for adults and youths who cannot attend the technical high schools or technical institutes in the day.

THE CINCINNATI SYSTEM. At the University of Cincinnati, Dean Herman Schneider, of the College of Engineering, originated a plan which he has been trying most successfully for several years, of co-operation with the shops of the factories whereby the students work part time in the University and part time in the shops.

Dean Schneider writes the author of this article that the same general plan is being tried successfully by the high schools of Cincinnati, and of several other cities in the United States, notably Fitchburg, Mass. If such co-operation can be supplemented by real supporting work in the high school, of special industrial value, the result should be real trade school work of great value.

On the whole, it must be confessed that industrial education in the United States is in a very elementary, chaotic and unsatisfactory state.

In an article next month we will discuss Iowa conditions as affecting the problem of the best plan for a system of industrial education in our own state.

Tests of a Chase Variable Speed Gas Engine

By Sern Madson, M. E., '11.

According to the commonly accepted theory the maximum efficiency of a gasoline engine can be attained only at a certain speed and power output. The coming of the automobile engine, however, seems to have disregarded this in some respects. The following set of curves were plotted from data derived from tests on an engine designed somewhat on the principles of the automobile engine and seem to show quite satisfactorily that the efficiency of a gasoline engine need not depend greatly on either speed or power output provided we remain within reasonable limits.

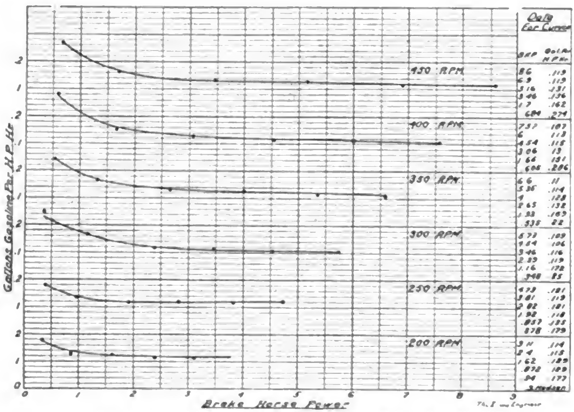
The theory of the Chase engine is that by varying the speed, timing the spark, and throttling the charge all in harmony with each other, the engine can be made to run efficiently on light as well as on full load. The engine is of the usual four cycle type, has hit and miss governor, jump spark ignition, and hopper cooling system. A simple Lunkenheimer generator valve or mixer was used in the test. It is provided with a control lever which simultaneously adjusts the governor for higher or lower speed, advances and retards the spark, and opens or closes a throttle valve in the gas intake. The speed varies from 200 to 450 revolutions per minute. One object of throttling the charge at lower speeds is to somewhat weaken the explosion and increase their frequency so as to cause less jerk which would otherwise accompany the decreased momentum of the fly wheels.

The size of the cylinder is 6x9 inches and the total weight of the engine about 1100 pounds. The weight of the fly wheel is 400 pounds. The tests were run on gasoline which tested 63 degrees Baume or weighed approximately 100 ounces per gallon. A counter was used to regulate the number of explosions so that the percentage of possible full load could be determined for any certain test. In no instance was this greater than about 80 per cent—the margin being reserved

to insure good governing. A prony brake was used and the gasoline consumption was determined by weight. The data for any one speed was obtained by running first the heavier load and decreasing by steps to zero load.

But little explanation of the curves will be needed. The tabulated data at the right is inserted for reference. Each curve represents the test for a certain speed as indicated. By a study of the curves we may come to the following conclusions:

The average 7 H. P. engine running on loads less than 2 to 3 H. P. will use considerably more fuel per B. H. P. than at higher power.



Curves showing the results of Tests on Chase Gas Engines

By reducing the speed, retarding the spark, and reducing the charge in proper proportion, the engine can be made to run efficiently on as low as one-half to three-fourths H. P.

The range of power that can be developed efficiently at each speed is reasonably wide; e.g. when set to run efficiently at 1 H. P. it will also develop 3 to 4 H. P. efficiently.

In addition to this the wear on the engine can be reduced by not running at high speed to develop low power as is often

demanded of an engine, especially when the same engine must be large enough for greater power and still is used for lighter jobs. It also has the advantage of being instantly adjustable to various speeds suited for different work and different machines. As regards fuel consumption it will be seen that in no case need it exceed 1 pint per H. P. per hour and it may be much less. Using 58 degree Baume naphtha in a like set of tests, the fuel consumption was approximately .125 to .13 gal per B. H. P. per hour.

Storm Sewer Design Based upon Experimental Data

The Bureau of Surveys of the Department of Public Works of Philadelphia has been carrying on a series of rainfall, discharge and tidal observations for the purpose of obtaining fairly reliable data to be used in the design of sewers.

The importance of obtaining records of both ordinary and extraordinary intensities of rainfall, as well as data showing the comparative relations of run-off to rainfall made under modern urban conditions, is very apparent when considered in its relation to the design of sewers.

In order to obtain information such as the above, it was necessary to provide instruments which would make automatic records regardless of the season or weather, and with a minimum of attention during their operation.

In order that the observations should be of value, it was necessary that they be made over a long period of years, as positive results could not be obtained unless there were years during which phenomenal conditions occurred. From the observations taken of various storms it was possible to make records showing the relation between rainfall and run-off, and which were of local value and applicable within the limits of those areas in which the observations were made.

Pluviometers were arranged at six different points in the offices of same of the district surveyors, and stream gauges were arranged in prominent sewers. Observations were made

Summary of Data Obtained From Gaugings of Dry Weather Flow, Made in 1910.

Name of area	Character of area	Point gauged	Area in acres		Population census 1910		Average Discharge per 24 hours.						Depth of flow ÷ diameter of sewer
							Gallons per day			Cubic feet per second			
			Total	Settled 1910	Total	Per Settled acre	Total	Per Settled acre	Per Capita	Total	Per Settled acre	Per Capita	
Thomas Run	Residential, mostly pairs of two and three story houses	Pine St west of Conestoga st	320	240	15 018	62.5	3 410 000	14 200	227	5 26	0220	000 350	088
		Conestoga St south of Pine St	426	337	21 677	64	3 320 000	9 860	153	5 14	0153	000 237	064
		Outlet of Cobbs Creek	1094	627	36 336	58	6 175 000	9 850	170	96	0153	000 265	066
Pine Street	Residential; mostly solid four to six story houses	Pine St between 25th and 26th Sts	160	156	15 152	97	4 105 000	26 300	271	6 35	0407	000 419	093
Shunk Street	Residential; mostly rows of two and three story houses	Shunk St at Bancroft St	208	208	25 754	123	2 190 000	10 500	85	3 39	0163	000 132	188
		Shunk St west of 18th St	331	331	37,916	114	3 516 000	10 600	93	5 44	0164	000 143	101
Lombard Street	Residential; tenements and hotels	Lombard Street at 3rd St	147	145	16 363	113	5 030 000	34 750	300	7 78	0536	000 475	114
York Street.	Residential and manufacturing	York St at Cedar St	358	354	33 340	94	12 754 000	36 000	383	197	0556	000 581	180
Market Street	Commercial	South side, west of Strawberry St	58	36 *	†	†	3 547 000	99 250		5.5	1536		135 ‡
		North side of Bank St	123	80 *	†	†	7 600 000	92 000		118	1435		156 ‡

* This area is practically entirely built up: the settled area is "total" minus "street area"

† The population contributing sewage is not shown by the census figures. ‡ Equivalent ratio in a circular sewer.

from time to time to determine the amount of flow in various large sewers by the use of a tide gauge and current meters.

From these latter observations in those sewers with inverts built of different materials where the factors in the Kutter formula were known and where the coefficient of friction was to be determined—it has been shown that the coefficient varies as follows:

Old sewers, brick bottom, not clean, - - n = .017
Old sewers, stone block bottom, clean, - - n = .017
New sewers. stone block bottom, clean, - - n = .016
New sewers, brick bottom, clean, - - - n = .015
Concrete or brick sewer, vitrified shale brick invert, clean, - - - - - - - - n = .012-.013
Concrete sewers, granolithic finshed bottom n = 011
In old sewers, bad and dirty bottoms, - n = .017-.020

In order to secure data for properly designing sewage collectors, twenty-four hour gaugings of the dry weather flow in sewers draining characteristic areas were carried on during the latter part of the year 1910. The areas of, and population upon, the drainage areas were determined so that the discharge of the sewers could be expressed in "gallons per capita" for different character of areas. The accompanying tabulation shows the results obtained from a number of these gaugings.

A New Method of River Improvement.

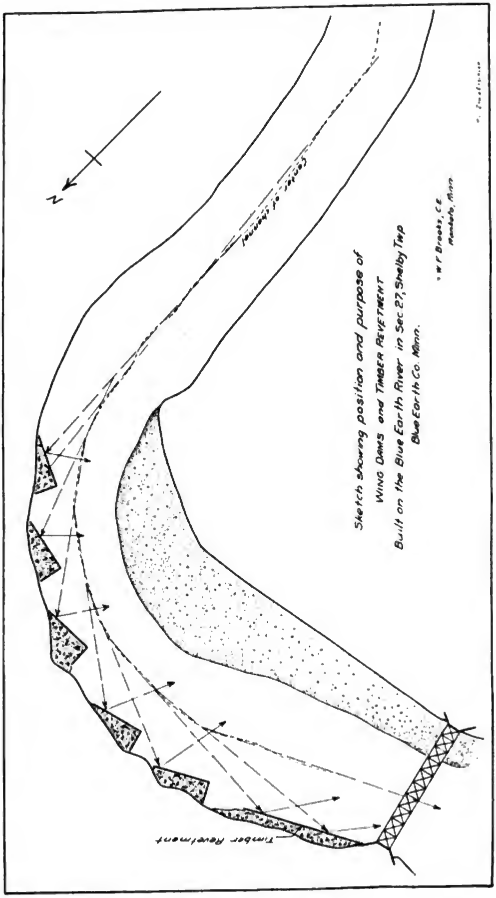
By Arthur Goldenstar, '15.

During the period of high water caused by the excessive rainfall in the summer of 1908, a bad case of bank erosion developed on the Blue Earth river a few miles south-west of the town of Amboy, Minnesota. This erosion began in a bend in the river as shown in the accompanying sketch. The soil at this place is a fine, loose, sandy deposit, carried down by early floods. Thus it could be expected that at such a sharp bend much erosion would likely take place. A steel

highway bridge is located just at the end of this bend, and the situation at once became serious because the water began washing away the fill around the north abutment, and finally undermined it sufficiently to cause the stone work to settle. As soon as this was discovered it was necessary to act immediately to save the bridge, and a new concrete footing, to a good depth was placed under the whole abutment.

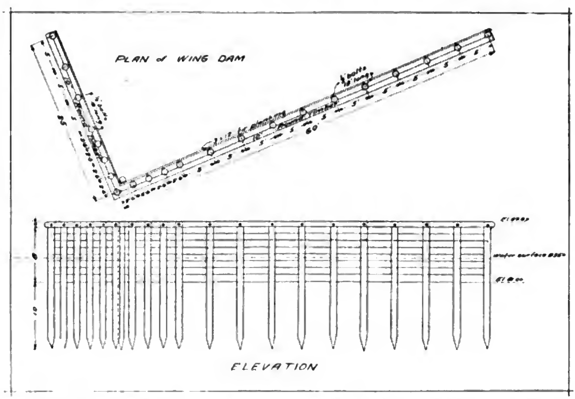
The whole problem was not yet solved however. The same thing would occur again if something were not done to direct the channel of the river more to the south end of the bridge, where it was when the bridge was located. Various schemes were thought of, two of which received consideration at some length. It was thought by some engineers that the river channel could be straightened by beginning about a quarter of a mile up stream. When an estimate of the cost of the excavation was made, however, the scheme was dropped as prohibitive. The other solution was the building of a reinforced concrete wall for a distance of about 600 feet along the north bank. The character of the ground made it necessary for the design to have more than ordinary depth and when the cost of the entire wall was figured this was also far above what the county thought it could reasonably spend. The idea of a timber wall or a revetment was also considered a little but did not seem practicable. It was while considering this plan however that the present scheme was suggested.

While studying the action of the current on the face of the wall, it could be seen that if something was done to direct the current against the sand bar on the south side of the stream, and cut it away, the channel might be shifted enough to bring the center of flow more to the south. The problem then was, at what angle would the water be reflected from a plane surface, and at what angle to the current should a wall be built to reflect it to the opposite bank. Upon investigation, there seemed to be no available information relating to just this sort of a proposition. Several engineers who had had experience in river improvement were consulted but none of them had ever studied the action of water in this way. They all seemed to agree however, that the general rule relating to light


Sketch showing position and purpose of
WING DAMS and TIMBER REVETMENT
Built on the Blue Earth River in Sec 27, Shelby Twp
Blue Earth Co. Minn.
W. F. Brooks, C.E.
Mankato, Minn.
Center of Channel
Timber Revetment
N

rays should apply here, that is, the angle of incidence would be equal to the angle of reflection. This matter was considered for some time and the engineer in charge finally decided to work out a scheme based on this principle.

The next step was to secure data that would show the channel and direction of the current at all points around the bend, and then to design a structure, or series of structures, that would oppose the line of flow. An accurate topographical survey of both sides of the stream and the river bed were then made. The water was quite low in the stream at the time and the center of the channel was accurately located. All the work was accomplished by the stadia method. A map



was then worked up on a large scale. It could then be seen that a series of short structures, placed at a sharp angle to the current would be far more effective in diverting the current, than one continuous surface all around the bend. It was also decided that these structures or dams could be built of piling planked up on one side, much cheaper and just as effective as an expensive concrete design. The final design was that shown by the accompanying drawing; the short wing of the dam to act as a brace for the longer wing, and the space between the wings to be filled with earth. The

lines showing the direction of the current were carefully studied and the location of each dam was made on the drawing. Five dams, with a short line of timber revetment were found to be sufficient. The dams were then located on the ground in accordance with the location on the drawing. It will be seen on the sketch that the dams are so placed, that at no point will the current flow between any two of the structures and get behind and undermine any one of them.

The dams were built early in the winter of 1908 after the river had frozen over. The total contract price including the back filling, was a little over $1700. This proved to be far cheaper than the estimate on any other design or plan suggested.

As the principle object was to direct the current more to the south end of the bridge, and also to cut away the long sand bar that had formed, it can now be said that the scheme has worked admirably. At the present time the sand bar has been completely cut away, causing the water to flow nearly under the center of the bridge and no longer endangering the north abutment. The only thing that could have been improved upon, is the strength of the dams. In several, the piles and planking have been broken by the floating ice in the spring. Had the piling been spaced closer, this would perhaps not have occurred. The general plan of all the work, including the design, surveys and location of the dams, is the work of Mr. W. F. Brooks, Civil Engineer at Mankato, Minnesota. The idea was original with him.

THE IOWA ENGINEER

Published Monthly During the College Year by the Students of the Division of Engineering, Iowa State College

Official Organ of the Iowa Brick and Tile Association and of the Iowa Association of Cement Users.

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EDITORIAL

With this number of the "Iowa Engineer", the newly chosen members of the staff present their maiden efforts. It is with a great many misgivings as to our fitness that we undertake this task. We shall no doubt make many errors while the magazine is under our guidance. For these we ask your indulgence. At the same time, we intend to make the magazine a true representative of the engineering division, and to that end ask your hearty co-operation.

The engineering school which we represent through this magazine is growing by leaps and bounds into one of the leading engineering schools in the West. Iowa now awake to her possibilities as a manufacturing state, is making more and more demands upon the engineering division. The Engineering Division must develop to meet these demands. Industrial Education is no longer to be regarded as merely desirable, it must be recognized as a necessary step in the development of the state. The employees of our factories and mills should be trained to be better workmen and more efficient wealth producers. That Iowa State College is to stand foremost in this movement is shown by the plans already under way, and by the askings which are to be made of the next legislature. We believe that the "Iowa Engineer" can help in carrying forward this idea, and it shall be one of our policies to keep Industrial Education before our readers.

During the past year there appeared in one of the leading engineering magazines, an editorial commending the "Iowa Engineer" as among the best magazines published by engineering students. The fact that the paper was truly a technical journal and not a news medium was the basis of this commendation. Although we shall attempt to give space to those news items which are of interest to our readers, yet we shall always consider the technical side of the paper as the more important. A clear cut engineering paper carrying with it the dignity of the profession—such is our plan for the coming year.

College Notes

There are many changes and additions in the personnel of the engineering faculty this year. It is to introduce the new members to the students and alumni, as well as to acquaint them with the location of the old members, that the following write-ups are given.

F. D. Paine is instructor and dynamo laboratory assistant in the electrical engineering department. Mr. Payne graduated from I. S. C. in electrical engineering in 1909. For some time

after graduation he was superintendent of the Electric Light Co. at Sanborn, Iowa. He then went with the General Electric Co. and completed the student course with that company before coming to his present position.

J. F. Ferm, B. M. E., '11, who has been instructor in drawing for the M. E. Dep't during the past year, will be with the Bethlehem Steel Co.

G. H. Montillon will have charge of all the freshmen drawing classes for the M. E. Dep't. He was graduated from the mechanical course last spring and had the distinction of being the honor student from his department. Mr. Montillon was with John Deere & Sons Co. of Moline during the summer.

John Hug, B. M. E., '09, has been promoted from instructor in the machine shop to instructor in drawing. All sophomore M. E. drawing classes will be supervised by Mr. Hug.

R. C. Riedesel is instructor in the machine shop. Mr. Riedesel graduated from I. S. C. in '08 with the degree of B. S. in M. E. Since graduation he has been actively engaged in various kinds of machine shop work. For two years he was in general machine shop work with the Hart-Parr Co., of Charles City, and during this time was night foreman and machine shop clerk. Besides several months experience on structural steel, Mr. Riedesel also spent one year in automobile repair work.

Oscar Negaard is student assistant in M. E. drawing.

Professor Adolph Shane has severed his connection with the Electrical Engineering Department of the college in order to take a position as head of the Electrical School of Highland Park College, Des Moines, Iowa.

Harold C. Bartholomew has been made Associate Professor of Electrical Engineering to fill the place made vacant by the resignation of Prof. Shane.

Frank A. Robbins has been promoted to an assistant professorship. Mr. Robbins was instructor in Electrical Engineering last year.

J. B. Verela has resigned as instructor in drawing for the M. E. Dep't and is now working on the design of heavy machinery for the Bethlehem Steel Co.

W. S. Bevan, B. S., '04, will instruct in the Physics Dep't of the Oregon State College at Corvallis, Oregon.

Amos P. Potts, B. S. in Ceramics, is now head of the courses in Ceramics Engineering. After Gradnation from High School Mr. Potts spent six years in the Cook Pottery Works at Trenton, New Jersey. In 1907, he entered Ohio State University and received his degree in Ceramics Engineering from the University in 1912. During the summer of 1909, he was with the Alma Cement Co., Wellston, Ohio, as night Chemist. He is the Junior Author of an extended report on the "Influence of Clay, Feldspar and Flint on the coefficient of expansion of certain white ware mixtures," which appeared in the Transactions of the American Ceramics Society in 1911.

C. Pomeroy, instructor in Physics is a graduate of Queens' College. He took post-graduate work at McGill University in preparation for extended research work, which he afterwords carried on in Princeton.

ENGINEERS CAMPFIRE

For once in the history of events, it did not rain on the date set for the Engineers' Campfire. With good weather in our favor and an official half holiday to go on, Oct. 2nd witnessed the biggest Campfire ever held at Iowa State College.

Early in the afternoon the procession of Engineers and Co-Engineers started out past the Vet. Hospital to the North Woods, where a large pile of wood indicated the center of attraction. Neat programs informed the crowds of the stunts that were to be pulled off under the supervision of Joe Shoemaker and his helpers.

Association football teams were chosen from each department to compete for department championship. Rivaling the Varsity in pep, these squads kept Profs. Fish and Hummel busy refereeing the game. The Ag. Engineers finally came off victorious, after they had beaten the Electrical and Civil Squads. Between games a take off on each political party was the attraction. The Suffragettes were out in gorgeous array, accompanied by the Ag.

Engineers; the Miners presented Woodrow Wilson riding the famous Democratic mule; and J. K. Shellenberger made up to represent Roosevelt. The Electricals with their steam roller, one plank platform, and lanky elephant did justice to the G. O. P.

After these festivities came the big feed. Seated on the grass around the lighted fire, everyone proceeded to empty their lunch baskets. Hot wenies, buns and fruit were served by the committee. In the evening an array of vaudeville talent interspersed with moving pictures kept the crowd until the campfire embers had burned away.

Every Engineer joins with us in commending Joe Shoemaker and his committee for the great success of the 1912 Campfire.

In preparation for the Engineers' Camp Fire a big booster meeting was held in Engineering Assembly on Sept. 14th. The room was filled to the limit with a most enthusiastic body of Engineers, who greeted Pres. Pearson in his first appearance before the student body. In company with Pres. Pearson was a company of representative newspaper men from all over the United States, as well as prominent men of the state. Of these men Mr. H. L. Rogers of the Chicago Daily News, Mr. Rogers of the New York Globe and Senator Lafe Young all gave short talks. Each expressed the highest commendation of the Engineering School at I. S. C. and of the booster spirit present in the meeting.

At the Campfire booster meeting of the Engineering Society, the conditions of membership were extended to include Freshmen and Sophomore Engineers as Associate members.

Since Jan. 1, the Highway Commission has checked the designs of over 150 bridges which are being built in Iowa, at a cost of $250,000. In addition to this, they are carrying on an investigation of the bridges of Clinton county, and have been the cause of several indictments made by the grand jury of that county.

Through the courtesy of Professor Meeker and the Engineering faculty, the "Iowa Engineer" now has its office in Engineering Hall. The room formerly used for Mechanical Research has been completely repainted and revarnished to accommodate our publication. In addition to this, the state allowed sufficient funds to equip the new office with up-to-date furnishings. Among the things added are a fine roll top desk and complete filing cases. Located as we now are in a place readily accessible to the student body, we believe that the paper will receive more support from its student readers. We invite them as well as the alumni to visit us in our new quarters.

The Iowa State Manufacturers Association and the Iowa Federation of Labor passed resolutions some time ago, favoring the establishment of a system of trade education for Iowa. Acting in accordance with this idea, Dean Marston made a thorough investigation of the conditions and finally drafted a plan similar to that used by Wisconsin. It is proposed to carry on the work in local shops all over the state by means of weekly classes held either in the day time or at night. Lectures will also be sent out by the new department and correspondence courses will be started.

An appropriation of $35,000 has been asked for the first year. The proposition has been heartily endorsed by the Board of Education and will no doubt be supported. In the next issue of the Engineer we shall be glad to report that the Engineering Extension Department is an assured thing for Ames.

The State Board of Education at a meeting held in Cedar Rapids on October 7, decided that the following changes should be made in the courses of the three state colleges; commencing next fall:

I. The engineering courses at the State University are to be discontinued and all equipment moved to Ames.

II. The Home economics department is to be transferred from Ames to Iowa City, and the General Science courses at I. S. C. dicontinued.

III. All courses leading to Liberal Arts degrees are to be discontinued at the Iowa State Teachers College. The college will become strictly a Normal Training School.

The board has taken the above action after a careful consideration of all interests concerned. They have consulted the opinions of the leading educators of the country and the plan to be carried out is believed to be the most satisfactory that could be adopted. For years there has been duplication and overlapping of several courses by the different institutions with the result that instead of working in harmony, each school has been a competitor of the others. The proposed change it is expected will eliminate this competition, as well as effect a considerable economy in the expenditures of the state.

Alumni Notes

F. W. Rowat, C. E., '12, is in Des Moines working with his father as a stone cutter.

J. L. Stephenson, C. E., '12, is instrument man for the Morgan Engineering Co., at Memphis, Tenn.

B. L. Taylor, C. E., '12, is county engineer for Woodbury county.

Warren G. White, C. E., '12, is with C. H. Young at Muscatine, Iowa.

S. E. Lacey, M. E., '12, is engaged in the drafting department of the Union Pacific Railway at Omaha, Nebraska.

G. M. La Sourd, M. E., '12, is located with the Iowa-Nebraska Public Service Co. of Missouri Valley, Iowa.

H. W. Paine, M. E., '12, has gone into the automobile repair business at Eagle Grove, Iowa.

D. G. Porter, M. E., '12, has been engaged since graduation by the Tri-City Light and Railway Co., at Davenport, Iowa.

H. P. Stearns, M. E., '12 has located in Winnebago, Minnesota. Besides acting as instructor of Manual Training and Mathematics in the High School, he also is director of the band at that place.

D. C. Thompson, M. E., '12, is with the Fairbanks-Morse Manufacturing Co., and is stationed at Beloit, Wisconsin. He is taking up one of the apprentice courses offered by that company.

G. A. Loomis, Ceramics, '12, has located with the Vincent Clay Products Co. of Ft. Dodge.

J. J. Jones, Mn. E., '12, is in the employ of the Ray Consolidated Copper Co., with headquarters at Hayden Arizona.

E. G. Amesbury, C. E., '12, and H. C. Molesbury, C. E., '12, are both located with the American Bridge Co., at Ambridge, Pa.

H. C. Beckman, C. E., '12, stopped off at Ames on his way to Sioux City where he will take up work with the C. & N. W. Railway. He will be employed in the maintenance Department of the company.

J. N. Arthur, C. E., '12, writes that he has been made county engineer for Dickinson county with Spirit Lake his headquarters.

H. F. Clemmer, C. E., '12, is in school again this year taking post graduate work.

Claude A. Cool, C. E., '12, has been employed as bridge inspector for Cerro Gordo county.

M. W. Cressler, C. E., '12, is located with the Trussed Concrete Co, in Des Moines.

Ira Craft, C. E., '12, is concrete inspector for the city of Portland, Oregon.

Jack Dodds, C. E., '12, is engineer in charge of the paving that is being done on the campus. The work is being done under the direction of the highway commission.

O. N. Gjellefold, C. E., '12, is county engineer for Winnebago county. His address is Forest City, Iowa.

G. R. Lemmon, C. E., '12, is employed with J. H. Wayne, C. E., at Council Bluffs Iowa.

W. V. McCowan, C. E., '12, is field draftsman for the Nebraska Transportation Company, of Omaha.

Clarence Moriarity, C. E., '12, is county engineer for Buffalo county, South Dakota.

W. P. Nemmers, C. E., '12, has been working for the Marsh Bridge Co. of Des Moines since graduation.

C. E. Olson, C. E., '12, is superintending the construction of a large bridge which is being built by Green county, near Jefferson. He is acting for the county as a representative of the Highway Commission.

W. A. Olson. C. E., '12, is doing construction work for the American Bridge Co., at Duluth, Minn.

J. A. Paulson C. E., '12, is with the Adel Clay Products Co., at Adel, Iowa.

S. L. Pomeroy, C. E., '12, is working for the Northern Pacific Railway Co., at Mandan, S. D.

Merle Rosecrans, C. E., '12, spent the summer in Ft. Dodge contracting sewer and waterwork construction with his father.

E. T. Nichols, M. E., '12, is City Clerk and Engineer at Atlantic, Iowa.

Boyd H. Walker, C. E., '12, is with the Rock Island R. R. Co. on construction. He is stationed at Manly, Iowa, at the present time.

M. E. Packman, E. E., '09, was a visitor at the "Iowa Engineer" office during the past month. Mr. Packman was formerly connected with the United Wireless Co., but has recently accepted a position with the Marconi Wireless Co., of New York. He has had charge of several large wireless installations during the past year.

H. A. Wilkinson, E. E., '12, is constructing engineer with the Alamo Engine and Supply Co. of Omaha, Nebraska. At present he is just completing an installation at Perry Kansas.

Ralph Chatterton, E. E., '10, who was college electrician last year has resigned his position in order to accept an instructorship in Highland Park College, Des Moines.

M. W. Pullen, E. E., '08, will instruct in John Hopkins University during the coming year. Mr. Pullen was in Boston Institute of Technology taking post-graduate work last year.

W. G. Lane E. E., '09, is located at Los Angeles, California, in the district office of the General Electric Co., as sales engineer.

R. L. Howes. M. E., '11, has accepted a very good position as instructor in the University of Pennsylvania.

C. H. Myers, M. E., '12, has been with the Peoples Light Co., at Davenport, Iowa since the first of July.

Mr. F. W. Linebaugh, M. E., '97, who has been manager of the Electric and Water Departments of Ames, has resigned his position in order to accept the superintendency of the Ft. Dodge, Des Moines & Southern R. R. He will be located in the company offices at Boone, Iowa.

P. V. Alexander, E. E., '12, has taken up an apprenticeship course with the Western Electric Co., Chicago, Ill.

E. R. Martin, E. E., '10, will instruct in the electrical engineering department at Yale University during the coming year. Mr. Martin after finishing an apprentice course with the Westinghouse Electric Co., took an extended trip through England and Scotland.

E. C. Brooks, E. E., '12, J. A. Burgeson, E. E., '12, and A. D. Gibson, E. E., '12, are all in the employ of the Ft. Dodge, Des Moines & Southern R. R.

C. P. Drake, E. E., '12, is with the Waterloo, Cedar Falls & Northern Electric Railway Co.

Floyd Beatty, E. E., '12, Jesse Group, E. E., '12, L. C. Stang, and E. A. Luney, E. E., '12, are all taking apprentice courses with the Westinghouse Co., at Pittsburg, Pa.

P. Koolish, E. E., '12, has gone into telephone work with the Nebraska Bell Telephone Co., at Omaha.

E. L. Fisher, E. E., '12, is located at Boone, Iowa, with the Ft. Dodge, Des Moines & Southern Railway Co.

H. A. Frommelt, E. E., '12, is with the C. M. & St. P. Ry., at Dubuque, Iowa.

Mr. Ray E. Blinn, M. E., '12, was seen on the Campus, Sept. 25. He is Bridge Inspector for Woodbury county and is working under the direction of the Iowa Highway Commission.

Mr. J. T. Booth, C. E., '09, who is at present Residence Engineer for the Grand Trunk Pacific Railroad in western Canada is spending a short vacation visiting in Iowa. Mr. Booth says there is a large field in Canadian Railroad Work.

Mr. F. E. Van Slyke, C. E., '10, recently paid his Alma Mater a short visit. He is located in the General Manager's office of the American Bridge Co., at Gary, Ind.

Chas. H. Schumacher, M. E., '12, is employed with the Hart-Parr Co., at Charles City.

E. P. Gibson, E. E., '12, and I. W. Hanson, E. E., '12, are both taking apprentice courses with the General Electric Co.

W. L. Fulton, B. C. E., '06, and wife of Omaha, Nebraska, visited for a few days on the campus early in October.

E. N. Harris, M. E., '06, now located at Seattle, Washington, was an Ames visitor on October 7.

J. C. Wagoner, E. E., '09, Ag. E., '10, is making good with the International Harvester Co., of Chicago as chief of the service bureau.

R. B. Gray '10, is foreign demonstrator for the International Harvester Co.

A. C. Longnecker, Ag. E., '12, is now located with the Avery Co. at Peoria, Ill.

Since graduation J. W. Gilmore, Ag. E., '11, has held the position of Ass't Prof. of Ag. Engineering at Manitoba Agricultural College, Winnipeg, Canada.

D. S. Wormley, Ag. E., '12, is instructor in the Indiana School of Practice Engineering connected with the M. Rumley Co., La Porte, Ind.

Raymond Olney, ex Ag. E., '12, is connected with the Publicity Department of the M. Rumley Co., of La Porte, Ind.

CONTENTS

ENGINEERING ANNEX—IOWA STATE COLLEGE

THE IOWA ENGINEER

VOL. XIII NOVEMBER 1912 NO. 2.

A System of Industrial Education for Iowa

By A. Marston*

Part II. The Present Situation in Iowa.

Before attempting to decide upon the outlines of a system of industrial education for Iowa it is necessary to study carefully such special Iowa conditions as may materially affect the problem.

The first fact worthy of special note is that our state has no extremely large cities, and very few of considerable size. Hence a satisfactory system of industrial education for Iowa must be especially adapted to small and medium sized municipalities.

The approximate distribution of Iowa's urban population between cities and villages of different sizes is shown in Table I, herewith, for the dates of 1890, 1900 and 1910, respectively.

The data in Table I are also shown graphically in Fig. 1 herewith.

Fig. 1 and Table I show very clearly the facts both as to the present distribution of Iowa population, and as to the tendencies for the immediate future.

One of the most striking of these facts is the relative increase of town population and corresponding decrease of rural population, as shown graphically at the right of Fig. 1. Twenty years ago the rural population was far in excess, but

*Reprint of an article in "Iowa Articles"—May and June 1912, by A. Marston, Dean of Engineering; Iowa State College.

now the towns have already slightly outstripped the country, and the tendency in Iowa is evidently strongly towards a large excess of town population over rural in the not distant future. The author of this article used such part of Fig. 1 as could then be constructed to illustrate a paper he was presenting in 1903 to the Western Society of Engineers, in Chicago, and called attention at that time to the probability,

TABLE I.

APPROXIMATE DISTRIBUTION OF IOWA POPULATION.

Population of Cities and Villages	1910		1900		1890*	
	Number	Total Population	Number	Total Population	Numbbr	Total Population
35,000-87,000	4	216,000	3	134,000	2	88,000
20,000-35,000	6	161,000	5	130,000	4	102,000
10,000-20,000	7	91,000	6	83,000	5	72,000
5,000-10,000	9	59,000	10	71,000	7	51,000
2,000- 5,000	**66	203,000	64	194,000	41	121,000
1,000- 2,000	91	123,000	98	133,000	75	105,000
500- 1,000	211	145,000	196	136,000	148	103,000
0- 500	443	121,000	302	92,000	180	60,000
Total villages and cities.	837	1,119,000	684	973,000	462	702,000
	....	=50.3%	....	=43.6%	....	=36.7%
	....	1,106,000	....	1,259,000	....	1,210,000
Strictly rural population	....	=49.7%	....	=56.4%	....	=63.3%

*Note 1. There are some discrepancies in the 1890 column which could not be removed.

**Note 2. In 1910 there were 35 cities 2,000-3,000, with 83,000 total population. In 1910 there were 31 cities 3,000-5,000, with 120,000 total population.

Note 3. For a more exact analysis of Iowa population see the forthcoming bulletin of the Iowa Engineering Experiment Station, Ames, Iowa, by Prof. J. E. Brindley, on "A Study of Iowa Population as Related to Industrial Conditions." Part of the apparent loss in strictly rural population between 1900 and 1910 is due to the incorporation of very small towns.

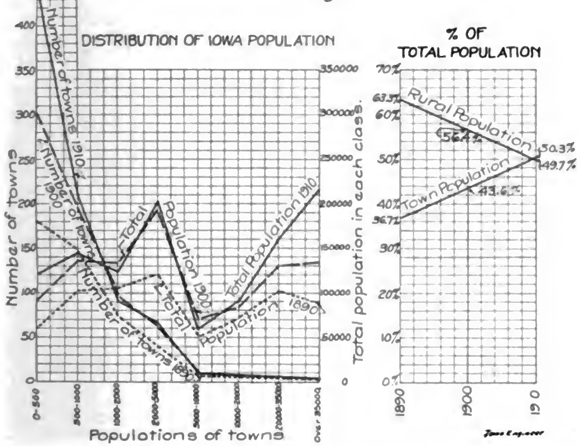
which has since been realized, that the town population of Iowa would exceed the strictly rural population at a date not far from 1910.

Fig. 1 and Table I also show clearly that the towns and cities of Iowa are of small size, individually, as compared with the more prominent industrial states. We have only 26 cities of 5,000 population and over, and these contain only about half the total town population (527,000 out of 1,119,000).

On the other hand we have 66 cities of 2,000 to 5,000 population, and 745 towns under 2,000. Any adequate solution for the problem of industrial education for Iowa must provide adequately and at small expense, for the industrial education of over half a million population living in towns and cities having less than 5,000 people each.

Fig. 1 and Table I also bring out the significant fact that practically the only growth in population anywhere in Iowa between 1900 and 1910 was in cities 20,000 population and

Fig.1.



higher. The rural population decreased very materially, and while the extremely small towns show an apparent increase, this is really due to the new incorporation of many very small towns instead of to any actual increase in size. Our larger cities are growing, however, and this growth is pretty sure to be accentuated by the future further development of our manufacturing industries. Hence, while Iowa has so far largely been free from the evils and difficult problems of the large city, it is now time for us to study how to prevent these evils,

and to adopt the soundest and best plans for industrial and social betterment.

THE PRESENT INDUSTRIAL SITUATION IN IOWA.

The present manufacturing industries of Iowa are, of course, most important in our larger cities, but are not confined to them. Moreover, any adequate system of industrial education for Iowa must provide for all trades, whether directly related to manufacturing or not. We must give the elevator boy and the driver of the butcher's wagon their chance with the rest.

Hence our future system of industrial education must provide for the small cities and the towns as well as for the larger municipalities.

Moreover, while it is true that many of the most important of Iowa's manufacturing industries have to deal with the products of our farms, yet there are already plenty of others, and those important also. Already our clay industries rank first among the states in one very important line, our manufacturers of transportation equipment and of ingenious machinery for various uses are very extensive, and our shops and factories are successful in many important manufactures. There is every reason to believe that we shall soon come to such a varied and extensive development of manufactures as may adequately supply the myriad wants of a great, rich and intelligent state, and enable us to compete on at least even terms in many lines with competitors elsewhere. Even our manufacturers of agricultural products require engineering and industrial skill of the highest order.

Hence a system of industrial education suited to Iowa's needs must be directly related to and controlled by the engineering and manufacturing interests of the state.

IOWA'S PRESENT PUBLIC SCHOOL SYSTEM. The problem of industrial education in Iowa, as shown by Table 1 and Fig. 1 above, is to provide the children belonging to a total 1910 population of 1,119,000 with such educations as may adequately equip them to attain the greatest efficiency

in the trades and industries which are to constitute their life's work. There will, of course, continue to exist a large and free interchange of individuals between town and country, and a considerable education of country youth in the town schools, but these facts do not change the general statement just made.

The query is naturally suggested, how far does our present public school system meet the general need for education in our towns and cities?

TABLE II

APPROXIMATE DATA OF SCHOOL ATTENDANCE IN IOWA TOWNS AND CITIES.

No. of Cities and Towns	Size of Cities and Towns	Total Population	School Enumeration	Total School Attenance	% Attendance of 75.7 % of Enumeration	Hifth School Attendance 1911	% High School of 23.6 % Enumeration
4	35,000 to 87,000	216,000	60,000	32,000	70%	4,200	30%
6	20,000 to 35,000	161,000	46,000	26,000	75%	3,200	30%
7	10,000 to 20,000	91,000	23,000	14,000	80%	2,200	40%
9	5,000 to 10,000	50,000	17,000	12,000	93%	2,100	52%
31	3,000 to 5,000	120,000	33,000	26,000	104%	5,700	73%
35	2,000 to 3,000	83,000	24,000	19,000	104%	4,300	76%
92	2,000 to 87,000	730,000	203,000	129,000	84%	21,700	45%
745	0 to 2,000	389,000	132,000	103,000	103%	12,300	40%
837	0 to 87,000	1,119,000	335,000	232,000	91%	34,000	43%

Note 1. The above data are only approximately correct, as numerous omissions in the reports had to be supplied by estimates. The errors may be of considerable magnitude, since the number of children in the United States of school age in 1900 would average 377,000 for a population of 1,119,000. The figures for school enumeration given above are hence probably too low, and the per cents of total attendance and high school attendance too high. The tuition pupils also help make these per cents too high, as does the fact that some pupils require extra time to finish.

Note 2. Of the high school attendance:

Males=Approximately 43% of total.
Females=Approximately 57% of total.
Seniors=Approximately 64% of average class.

It is impossible to secure absolutely exact statistics of our public schools. The State Superintendent of public instruction publishes an educational directory each year, but he has to rely upon local authorities who are not legally bound to do the work, and even those who do respond cannot afford the time or expense to prepare absolutely reliable reports,

Hence the published data show many omissions and some discrepancies.

The writer has supplied the omissions and reconciled the discrepancies in the Iowa Educational Directory for 1911-12 as best he could, and gives the results in Table 2, herewith.

In calculating the per cent columns of Table 2 an effort has been made to show a rough comparison with what the total school attendance and the high school attendance would have been if every child except those removed by death had completed the full course, including the high school. No accurate comparison of this kind is possible. The per cents given were determined by taking the proportionate number of children for each age from the census for 1900 (since the figures for 1910 are not yet available), and assuming that the same proportion would hold in this case. If this were true the total possible school attendance would be 75.7 per cent, and the total high school attendance 23.6 per cent of the enumeration of children and youth of 5 to 21 years ages.

While Table II is not very precise it is accurate enough to give some light in a very interesting way upon what our present schools are doing for the children and youth of Iowa.

The writer of this article heard a prominent Iowa newspaper editor state not long since, in a public address, that 98 per cent of our youth never reach the high schools. Evidently he was very badly mistaken as to conditions in Iowa. At least eight times as many of the youth of our Iowa towns graduate from the high schools as he stated.

Nevertheless, we must admit that even in Iowa the great majority of our boys and girls fail to obtain a high school education. In our larger cities even now at least five out of six of our boys fail to complete a high school course. The great majority never even enter the high school.

Table II shows very clearly that, as a general rule, the larger the city the less the per cent of Iowa youth who receive complete public school educations. Even after making all possible allowances for tuition pupils, it would still appear that our towns and smaller cities come nearest the ideal in this respect, so far as numbers alone are concerned.

If Iowa's industries are to grow, and her cities increase in size, both of which developments seem certain, it is plain that we should take measures at once to provide for the industrial education of the youth of our cities, to forestall and prevent the evils which prevail in great industrial centers elsewhere.

One serious trouble with our public schools, insofar as they fail to interest and hold our youth, and insofar as they fail to do their part in securing national efficiency, is that they do not train their pupils to do anything in particular for life work.

We have devoted and capable teachers who are earnestly striving to improve our public schools. They have not entirely overlooked the need for industrial training, but are groping towards it, with many obstacles in the way.

MANUAL TRAINING was first introduced into American high schools in 1874, and with the idea that it would provide industrial education. But, to use the words of the Wisconsin Commissioner's report, "it has failed to accomplish what was fully expected of it, in that it has not provided industrial education. Manual training in the high schools has served its educational purposes, but has entirely failed to give industrial training." Hence, Massachusetts, where manual training was first introduced, has for a considerable number of years been developing real trade schools, along various lines, together with continuation work and evening classes.

The real function of manual training is to educate the hand and the eye, as well as the mind. It should be considered a necessary part of a well rounded education, and is of very great importance and value. It does not, however, fit young men for any special trade, and hence fails to meet the real aim of industrial education. Manual training should be introduced into all our graded schools, and the work should begin at about the 5th grade, so that boys who fail to go on into the high school can have the benefit of its training. Even when this is accomplished to the fullest extent, however, there will still remain about the same necessity for real industrial education which now exists. Actual experience in correspondence work in Wisconsin shows that the average

workman in American shops is unable to perform satisfactorily ordinary calculations in simple fractions. We are proud of our schools, but the majority of our boys leave them before receiving much education, and it seems plainly apparent that these boys can be reached only by real industrial education.

Manual training is of large and growing importance in connection with the public schools of Iowa, as is clearly shown by Table III, herewith, compiled from the Iowa Educational directory for 1911-12.

TABLE III.

NUMBER OF MANUAL TRAINING DEPARTMENTS IN IOWA SCHOOLS.

Date	No. in Operation	Date	No. in Operation	Date	No. in Operation
1887	1	1896	7	1905	25
1888	1	1897	7	1906	42
1889	4	1898	7	1907	54
1890	4	1899	7	1908	66
1891	4	1900	7	1909	74
1892	5	1901	8	1910	92
1893	5	1902	9	1911	101
1894	5	1903	13	Not dated	1
1895	5	1904	16	Total	102

Note 1. The numbers given above allow separately for different departments in different high schools in the same city, but not in different grade schools.

Note 2. Statistics of number of pupils taking manual training in 1911-12 are missing for Cedar Rapids, Ida Grove, Wapello, and Winfield. With these exceptions, the number of manual training pupils in 1911-12 is 8845 below 9th grade, and 3207 above 8th grade, making a total of 12052.

THE IOWA STATE COLLEGE OF AGRICULTURE AND MECHANIC ARTS, AND ITS RELATION TO INDUSTRIAL EDUCATION FOR IOWA. While our state has not as yet established any industrial education along general industrial or manufacturing industrial lines, it has made a real and effective beginning at industrial education in one particular industry, namely agriculture. It has accomplished this through the agency of the Iowa State College, at Ames. Under the provisions of various national and state laws, this college has

provided extensive agricultural work along four lines: First, strong four year professional agricultural courses, of college grade; second, an amply supported agricultural experiment station, for scientific agricultural research; third, a two year agricultural trade school course, below college grade; fourth, agricultural extension work, by which agricultural educational work is brought within the reach of thousands of farmers and farmers' boys and girls all over our state.

Combined with these four lines of work is the training of technical agricultural teachers, in a regular college course and in a six weeks summer school.

In this special line industrial education (namely, agricultural), America is ahead of any other country, and Iowa well to the front in America. In fact, no other industry, probably, has ever had so much done for it by the state in the way of state research and education, as agriculture. In Iowa, the regular college work in agriculture at the State College receives a large proportionate share of an annual income of $481,000 per year, besides special state appropriations of $85,000 per year for Agricultural Experiment Station work, $25,000 per year for 2 year agricultural trade school work, and $50,000 per year for agricultural extension work. All the above is in addition to an annual state appropriation of $50,000 per year for state aid to high schools teaching agriculture.

While the annual expenditures for state agricultural education are thus very large, the people of the state do not grudge the money for they realize that the benefits are correspondingly large, and more than repay the outlay.

Since the strictly rural population is now less than one half the total population of Iowa the query naturally arises whether the state and the state college should not do the same work in Iowa for industrial education in general which they are already doing for agricultural education alone.

THE PURPOSE OF THE STATE LAND GRANT COLLEGES AS DEFINED BY THEIR ORGANIC LAW INCLUDES MECHANIC ARTS JUST AS MUCH AS AGRICULTURE. The best evidence as to the purpose of the va-

rious land grant colleges, such as the one at Ames, is the organic law passed by congress in 1862 to establish them. This act, now known as "The Morrill Law," very clearly and specifically defines their character and purposes in the following language:

"The interest of which (national endowment) shall be inviolably appropriated by each state, which may take and claim the benefit of this act, to the endowment, support and maintenance of at least one college, where the leading ob-

Engineers studying industrial needs by actual practice.—Iowa State College Foundry.

ject shall be, without excluding other scientific and classical subjects, and including military tactics, to teach such branches as are related to agricultue and the mechanic arts, in such manner as the legislatures of the states may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions of life."

It thus appears that the very same organic law, and very same section of that law, which assigned agricultural education to Iowa's state college also assigned to it general industrial education. It may, therefore, properly be considered the plain duty of the authorities of Iowa's State College to cooperate with the manufacturing and other general industries of Iowa to the fullest extent, and to do as much for general industrial education in the state as for agricultural education.

ENGINEERING EDUCATION AS A PART OF INDUSTRIAL EDUCATION. The State College at Ames has, since its foundation, had strong engineering courses, established in compliance with both the national law, given above, and additional specific state laws. There are now about 600 engineering students in these courses. In common with the other land grant colleges the attempt was first made to establish mechanic arts work of lower than college grade, although the law specifically calls for college work. Bitter experience has forced or is forcing all the land grant colleges to do work of strictly college and professional grade, both in engineering and in agriculture, for the boys of 14 to 18 years of age, who need trade school work, will not go off to school at a distance from home. In the present two year trade school work in agriculture at Ames for example, only 154 farmers' boys attended out of probably 75,000 in Iowa.

There are other engineering schools in Iowa, and the majority of engineering graduates have so far gone out of the state, because the demand outside is greater, and the pay larger. About 30 per cent of those at Ames remain in Iowa, and the authorities there would welcome a systematic cooperation with Iowa manufacturers, on a modified "Cincinnati plan," which would keep many more of our engineers at home to help develop Iowa industries. This is one important improvement in industrial education in Iowa which might be effected at very little expense.

INDUSTRIAL EXTENSION AND CORRESPONDENCE STUDY WORK are not yet established at our State College, but should undoubtedly be in the immediate future. In Wis-

consin, such work has been established under direction of the able engineer, Dean Reber, who addressed the Sioux City meeting of The Iowa State Manufacturers' Association on the subject of industrial education. The work is most highly successful, and is of the very greatest benefit to the state. Although it was begun only six years ago, it has grown so rapidly that already about 4,000 students are registered in its courses.

An Outline of a Possible System—For Discussion

IOWA'S OPPORTUNITY. A prominent industrial educator has expressed the opinion that Iowa has now a great opportunity to assume the leadership in the United States in industrial education. Having established absolutely nothing so far in the way of trade schools, and standing at the threshold of our manufacturing development, we can adopt the very best and most advanced plans for a statewide system, and can use industrial education in the most scientific manner to aid in the growth of our manufacturing industries. We can, if we will, forever prevent many of the evils which a massed population often suffers as an accompaniment of great industrial development. In place of the ignorant, unskilled, and poverty ridden day laborer of the tenement district, we can substitute the intelligent, educated, highly skilled and well paid mechanics of an American home.

SUCCESSFUL INDUSTRIAL SCHOOLS FOR IOWA MUST BE UNDER DIRECT CONTROL OF EMPLOYERS, EMPLOYEES, AND TECHNICAL MEN, BUT MUST ALSO BE COORDINATED TO OUR PRESENT PUBLIC SCHOOL SYSTEM. Under no other plan can industrial schools be developed in Iowa which will really meet our varied industrial needs. If such schools are actually to fit men for trades, they must be controlled by men engaged in the trades, and the work must be done by men with trade experience and technical education.

MECHANIC ARTS EXTENSION AND CORRESPONDENCE STUDY WORK SHOULD BE ESTABLISHED AT

ONCE, ON A LARGE SCALE. This work should be modeled closely after that which has proven so successful in Wisconsin, and which Dean Reber will undoubtedly describe at the Sioux City meeting. The work will involve the following principal features:

Engineers in pattern shop—Iowa State College

It will have the same relation to the Mechanic Arts Division of the State College at Ames which the Agricultural Extension work already has to the Agricultural Division there, and will thus meet the obligation implied in the organic law of the college, that it shall do equal work for agriculture and for mechanic arts.

It will involve the districting of the state for industrial extension work, with sub-centers at various convenient points, and district instructors resident therein.

It will involve the establishment and maintenance of exten-

sion continuation and evening classes for youth and adults actually engaged in the industries of the state, in cooperation with the local authorities of towns and cities where such extension classes are found to be feasible and necessary.

It will involve the enrollment of thousands of workmen,

Forge Shop—Iowa State College

both minors and adults, in correspondence studies which they can carry on at home.

PROVISION SHOULD BE MADE AT ONCE FOR A SYSTEM OF STATE AID INDUSTRIAL SCHOOLS. This system should involve the following principal features:

The industrial schools should be established at points in the state where there is a real demand, as evidenced by willingness to pay at least say one half the cost.

They should be under control of local boards, composed of employers, employees, and at least one representative of the

present public school authorities.

They should be subject to state regulation and inspection before receiving the state aid.

They should be adapted to the local industrial needs.

They should provide for constitution and evening classes for minors and adults actually at work in the trades, and also for trade schools, in large industrial centers, where technical trade instruction of high grade is given in special local industries.

THE ABOVE PROGRAM IS FEASIBLE FOR IMMEDIATE ADOPTION AT VERY MODERATE STATE EXPENSE. From an excellent authority actually engaged in similar industrial extension work in another state, an estimate has been obtained that a good start can be made at the system of industrial extension and correspondence study work outlined above for $35,000 per year.

A careful estimate shows that the annual state appropriation needed for state aid industrial schools need not exceed $50,000 per year. This would make a total of $85,000 per year.

The state of Iowa already appropriates $50,000 annually for Agricultural Extension, $25,000 annually for an agricultural trade school at Ames, $50,000 annually for state aid to high schools giving agricultural instruction or a total of $125,000 annually for agricultural education work along lines similar to that for which the $85,000 suggested above would serve, although the strictly rural population of Iowa is now less than one half the total.

Diagrams for Solving Engineering Formulae and the Determination of Experimental Equations

G. F. Dodge, M. E. '98.*

A subject of continually increasing interest to engineers is indicated in the above title if one is to judge by the subject matter appearing in current technical papers, and when we consider the ease of present day communications it becomes a rather surprising fact that foreign engineers, notably the French and German, have been many years ahead of the American engineer in their application of diagrams to the quick solution of the formulae of everyday occurrence.

The main portion of this article will be devoted to an explanation of the methods to be followed in constructing diagrams for solving such formulae, and particularly those having more than three variables while the latter portion of the subject, viz., the determination of experimental equations, will be touched upon more or less incidentally, but the few cases shown and the following explanations of the properties of logarithmic paper should make it easy for the reader to work out for himself a solution for almost any condition of ordinary occurrence.

With ordinary coordinate paper and its uses all engineers are familiar and most of them make use of a slide rule as one of their shortcut methods, but few indeed seem to know anything of the use of logarithmic paper which might be said to bear the same relation to ordinary coordinate paper that the slide rule does to the pencil and pad. In fact all of the methods to be explained later and for which logarithmic paper will be used could be followed also with ordinary paper just as the pencil and pad would in time reach the same result as the slide rule. There is one notable difference, however, in these comparisons in that although the slide rule gives less accurate results than the pencil and pad, logarithmic paper does not

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suffer in comparison with ordinary coordinate paper. In fact, if anything, it has the advantage, for whereas the percentage of error is constant throughout its range of values, the error rapidly increases on ordinary paper as the values approach zero, or the origin.

This brings forth the observation that with log paper there is no origin, that is, no finite origin. It is away off in the

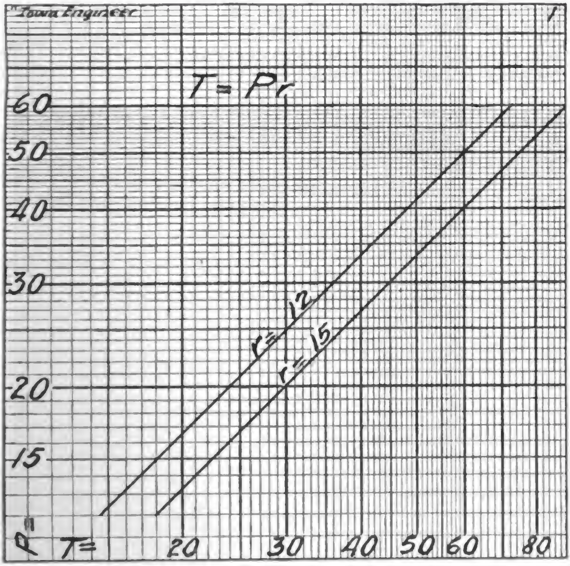

Fig. 1.

realms beyond imagination at that nebulous place called "Infinity" by Prof. Stanton. In this lack of finite origin lies one of its most valuable properties in that the plotted results of any series of direct multiplications or divisions will give a series of parallel lines. (The only origin at which they can meet is at infinity.)

Take for example the expression for torque in a shaft, T=Pr,

assuming two constant radii r = twelve and fifteen inches and plotting for each value with torque as abscissas and load P as ordinates the parellel lines of Fig. 1 result.

Inspection of these lines discloses the fact that they are straight and inclined at an angle of 45 degrees. This may be stated as a second property of log paper. *All* expressions involving only simple multiplication or division give straight line "curves," and if abscissas and ordinates are both of the first degree the lines will be inclined at an angle of 45°.

Using the same expression but transforming it into $P=T/r$ and plotting for a constant value of $T=1000$ using P and r as ordinates and abscissas respectively, the 45° line resulting, slopes upward to the left Fig. No. 2, while those of Fig. 1, sloped up to the right. The relation of slopes shown in Figs. 1 and 2 may be stated in a general rule, viz., if either abscissas or ordinates are the product of the other into the constant, the result will be a line extending up to the right; if either be the quotient found by dividing the constant by the other, the result will be a line extending up to the left. This rule is general and applies also to quantities of other than the first degree whenever the expression is one of simple multiplication or division.

The effect of quantities of other than the first degree, when used as abscissas or ordinates, is shown in Fig. No. 3, where has been plotted the expression for the bending moment in a uniformly loaded simple beam, $M=wl^2/8$, with moments as ordinates and lengths as abscissas and two values of load per ft. Straight parallel lines again result, but they are not at an angle of 45°. A close inspection discloses the fact that they make an angle with the l axis the tangent of which is two, the index of the power to which l is raised. This is found either by extending the line up and down until it reaches across one section horizontally and measuring the number of sections crossed vertically in that horizontal distance, or by measuring the angle with a protractor, and shows on the paper in Fig. 3 in that the lines rise two sections while passing one section horizontally indicating a second degree quantity as the tangent of the angle is two. Measuring the angle by a protractor gives an angle of 63°30′, the tangent of which is two.

Stated generally, quantities of other than the first degree when represented on one axis; with first degree values on the other axis, will give lines at an angle with the first mentioned axis, the tangent of which is equal to the index of the power to which the quantity has been raised.

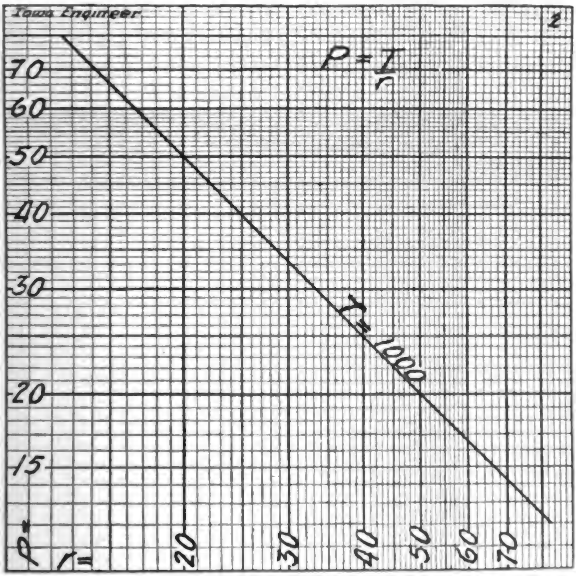

Fig. 2.

Were the formula such that "1" were cubed instead of squared, the lines would have risen three sections while passing one section horizontally. If now in addition to having "1" cubed, we have "M" squared, the line will pass three sections vertically while reaching two sections horizontally. This comes back to our rule, for the expression could be transformed so that moments would be of the first degree while "1" would then enter with a fractional exponent as 3/2 which is the tangent of the angle the line would make with the "1" axis.

One step farther and we see that the angle becomes 45° when both axes represent quantities of the same degree irrespective of whether quantities are of the first degree, for in this case

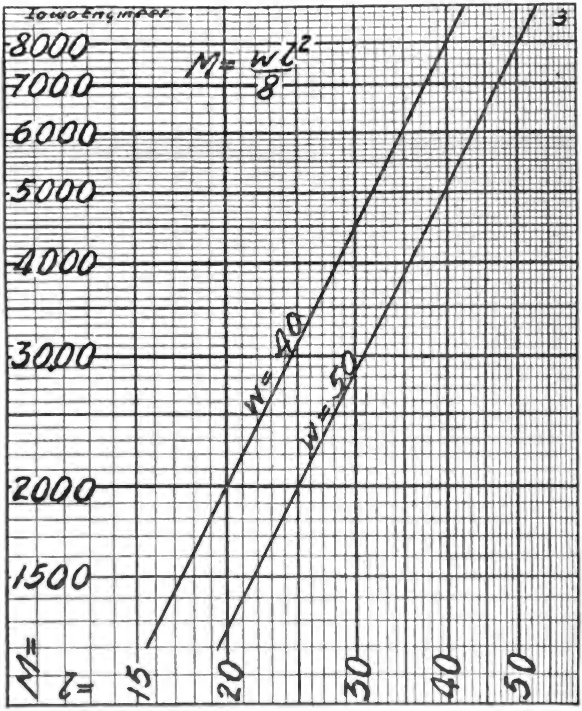

Fig. 3

both can be reduced at the same time to an exponent of unity. Therefore, when both ordinates and abscissas represent quantities of any equal degree the degree of the plotted quantity will have no effect on the slope. This is indicated in Fig. No. 4

where the formula of Fig. No. 3 has been plotted with "w" as abscissas and "l" as a constant. The quantity "l" is of the second degree while "M" and "w" are of the first and equal, but a 45° line results notwithstanding the degree of "l."

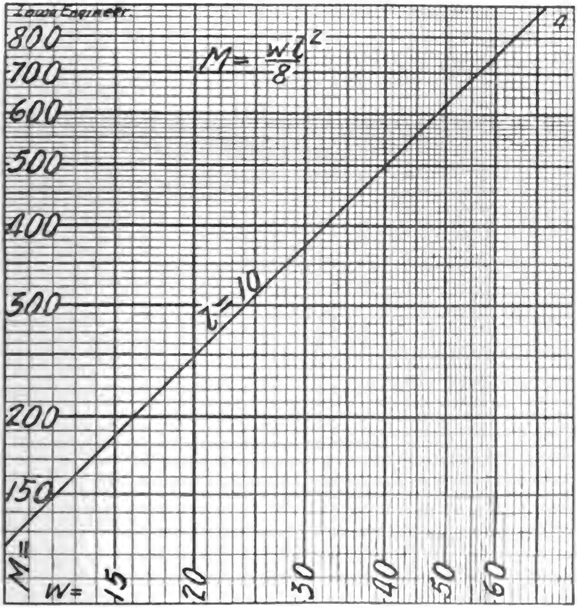

Fig. 4

Another property that is both advantageous and disadvantageous is that wherever an addition or subtraction enters an expression being plotted a curved line results, as in Fig. No. 5, where is plotted the expression $a = \frac{b}{3} + c$ with "a" and "b" as ordinates and abscissas respectively and with $c = 1$. This property is a disadvantage when plotting a series of lines for

it necessitates the calculation of a large number of points on each curve instead of but one as would be the case if the "curves" were straight lines at a known slope. Its advantage appears when determining an equation from experimental data. A curved line immediately gives evidence of a subtraction or addition in the expression and here ordinary paper comes to our help in determining the value of the added element.

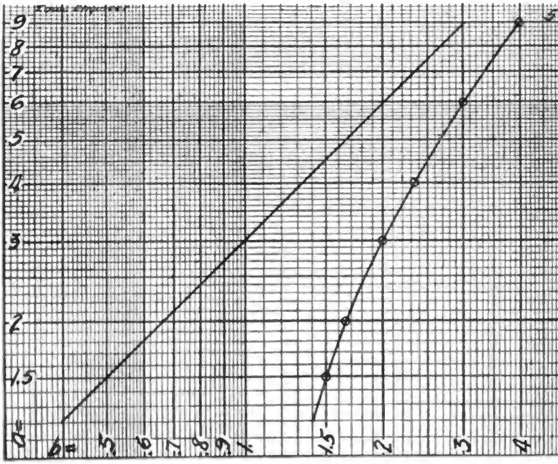

Fig. 5

Consider the curve of Fig. No. 5. Assume the equation unknown. The curved line indicates a plus or minus value in the equation. If this expression be plotted on ordinary paper, Fig. 6 and the line extended until it cuts the "a" axis, the value of "a" where the line cuts the axis, or rather where $b=0$, will indicate the value of the added constant $c=1$. Subtracting this from the values on the curve of Fig. No. 5, results in the straight line on this same figure. As this is a 45° line the equation is known, from previous statements,

to represent the multiplication of quantities of equal degree and an inspection of values shows "b" to be three times as large as "a," from which we deduce the expression $a = \frac{b}{3}$ plus the quantity subtracted, hence $a = \frac{b}{3} + 1$ is the full

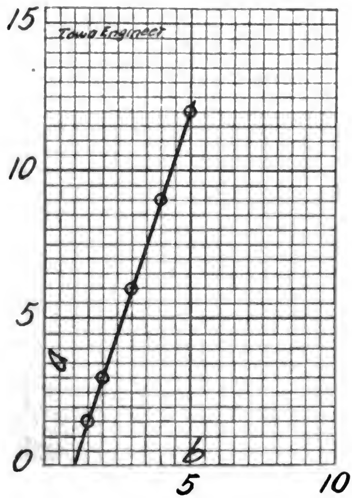

Fig. 6

equation of the curved line. This crudely simple case illustrates the underlying principles and suggests a line of attack in more complicated cases. In this particular instance ordinary paper would serve as well as log paper, but as has been explained, exponential expressions give straight lines on log paper and curves on ordinary ruling. Therefore the greatest value of log paper in experimental equations lies in its adaptability to the determination of exponents. Take the example of Fig. No. 7 which may be considered to represent the average of the experimental values indicated by the plotted dots as

determined for the relations of volume and pressure of steam when expanding adiabatically. These values plotted on ordinary paper would result in the familiar hyperbolic curve from which it is rather difficult to deduce the correct exponent. In Fig. 7 however we find the sloping straight line from which by means of the previously explained method we may deduce the

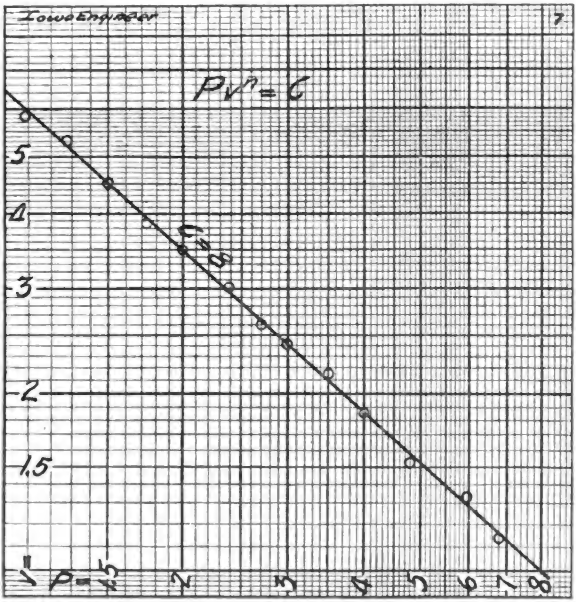

Fig. 7

exact exponent of v, in the expression $Pv^n = C$, for the case under consideration. This is found to be $\frac{10}{9}$ when the slope of the line is measured.

Turning now to the principal object of this article a few examples will be given to indicate the methods to be followed

in plotting diagrams that are to be used for obtaining quick solutions of formulae already known, universal tables in fact. The examples given are from a number that the writer recently worked up for use in the engineering department of the Company with which he was then associated, and are reproduced by the courtesy of that Company.

In figure 8 is given a diagram for finding the proper diameter of shaft when subjected to combined bending and torsion. This diagram is based on a solution for equivalent torsion given by Professor Hancock in the Engineering Record of Oct. 9, 1909.

This formula which seems to the writer the most logical of any yet proposed is as follows:

$Te = \sqrt{T^2 + 1.66\ M^2}$ in which

Te = equivalent torsion in inch lbs.

T = torsion in inch lbs.

M = bending moment in inch lbs.

1.66 = constant for mild steel found experimentally.

To secure a formula for the diameter of shaft required, it is necessary to combine the above with the familiar formula for torque alone.

$d = \sqrt[3]{\frac{5.1\ T}{S}}$ in which

T = torque in inch lbs. and,

S = maximum fiber stress in the material.

This is accomplished by substituting the value of Te from the first equation and results in,

$$d = \sqrt[3]{5.1\left(\frac{T^2 + 1.66 M^2}{S}\right)}$$

This last equation contains four variables and cannot be expressed in the ordinary way although it is evident that any three variables may be plotted throughout the range of their values by assigning a constant value to one of them and plotting this value throughout the range of the other two quantities, then assigning a new constant value to the one and plotting this; repeating until all desired values of the first variable have been taken care of. The result will be a dia-

gram with a series of lines representing values of the first variable with the second and third variables represented as abscissas and ordinates.

In our case the first formula may be plotted directly as the first step in the diagram, so arranging it as to give values of equivalent torsion Te as results. This is indicated by the curved lines of the first section of Fig. 8, the abscissas represent Te.

The second section solves the second equation with Te substituted for T.

Fig. 9 is given as an illustration of a condition where the number of variables involved requires more than two steps. The first step is plotted to show the relation between tons per hour, weight per cu. ft. and cubic ft per hour, giving cu. ft. per hour as the result when the tons per hour and weight per cu. ft. are known. In the second step is plotted the result of the expression,

$\frac{\text{cu. ft. per hr.} \times 1728}{\text{ft. per min.} \times 60}$ using the abscissas of the first step and finding as ordinates the cubic inches carried per ft. of elevator. This is divided in the last step by the spacing of buckets and gives as a final result the net capacity of each bucket in cubic inches.

The second step illustrates the fact that any number of constants may be treated in the same step without complicating results, as the final effect is simply that of multiplying the whole series of values by a constant, and is evidenced only in the location of the series of lines in the step. The whole group being moved up or down equally depending upon the value of the constant being used.

Fig. 9 also illustrates an expedient that may be resorted to when it is necessary to reduce the dimensions of the completed diagram. As is often the case when using standard sheets of log paper, various groups of lines will be widely separated and these may be brought together by cutting out the intervening blank spaces and mounting as shown.

In Fig. 9 the second step has been moved up through considerable distance and the third step moved up with the sec-

ond and horizontally, both movements having the result of greatly reducing the final dimensions of the diagram and permitting its reproduction at a much larger scale.

Fig. 10 is a good illustration of concentration and gives the horsepower of steel or cast iron gears according to Lewis' formula at various revolutions per minute using two-thirds Lewis' values.

Ordinarily any formula requires as many steps less one as there are variables in the equation, and when any variable enters a second or third time additional steps are needed. It is often possible however to find values of some variable in terms of another and by that means eliminate the step that would ordinarily be required in the diagram to consider its value. In this diagram several such eliminations have been made and the final solution brought down to a two step diagram notwithstanding the fact that solving for horsepower adds to the original four variables of the equation,

$W = spfy$

In which,

W = load at tooth

p = circular pitch in inches

f = face in inches

y = arbitrary tooth factor depending on number of teeth.

s = stress in material depending on velocity of pitch line.

The horsepower transmitted by a gear is the product of the load at the tooth W, multiplied by the velocity v, in feet per minute and divided by 33,000.

This may be written,

$$\text{H. P.} = \frac{Wv}{33000} \text{ or}$$

$$\text{H. P.} = \frac{spfyv}{33000}$$

As a very common practice makes the face of a cast gear three times the pitch we may write,

$f=3p$, thus eliminating f and reducing the expression to

$$\text{H. P.} = \frac{s\,3p^2yv}{33000}$$

In Fig. 11 the tabular values given by Lewis for s under varying velocities, have been plotted with velocities as abscissas and the line of average values drawn.

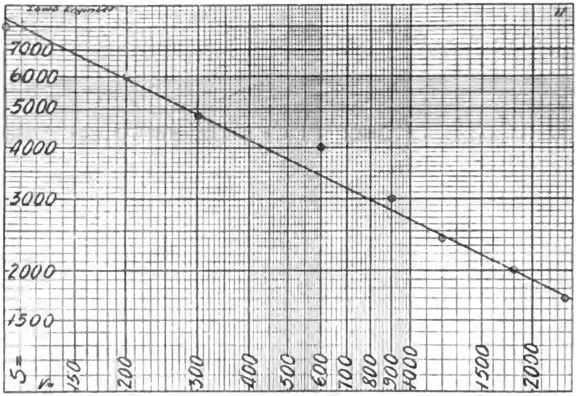

Fig. 11

Measuring the slope of this line with a protractor we find the angle to be 26°-34′, the tangent of which is ½ and therefore v enters to the ½ power or as $\sqrt{v}$. From the early discussion of the properties of log paper we find that the equation is $s = \frac{84000}{\sqrt{v}}$ thus eliminating s and reducing the expression to

$$\text{H. P.} = \frac{84000}{\sqrt{v}} \times \frac{3p^2yv}{33000} = \frac{84}{11}p^2y\sqrt{v}$$

In a like manner Fig. 12 represents Lewis' values of y plotted with n as abscissas.

The straight line drawn is seen to be a very good average of all values up to twenty-seven teeth and as the pinion is the weaker of a pair of gears we may ignore higher numbers of teeth and use the values given by the line of averages, designing always for the pinion.

Iowa Engineer

[illegible]

By the same methods as for Fig. 11 the equation of this line is found to be,

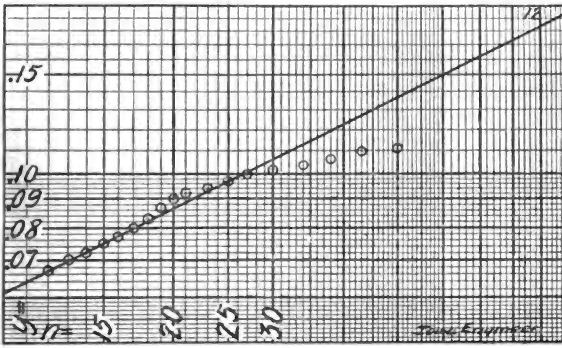

Fig. 12

$y = .0192\sqrt{n}$, and thus y is eliminated reducing the general expression to,

$$H. P. = \frac{84}{11} p^2 \sqrt{v}\ .0192 \sqrt{n}$$

Squaring this we have,

$$H.P.^2 = 7.64^2\ p^4\ v\ .0192^2\ n$$

Now v, velocity in feet per min. is expressed thus,

$v = p\dfrac{nR.P.M.}{12}$ and this substituted in the last form of the general equation gives,

$$H.\ P.^2 = \frac{7.64^2\ p^4\ .0192^2 n\ pn\ R.\ P.\ M.}{12} = \frac{7.64^2 p^5\ .0192^2\ n^2\ R.P.M}{12}$$

$$H.\ P. = 7.64\ n\ .0192\sqrt{\frac{p^5\ R.P.M.}{12}} = .04233\ n\sqrt{p^5}\ \sqrt{R.P.M}$$

A tabular comparison of horsepower values given by various manufacturers of cast gears discloses the fact that values given by Lewis exceed a good average by about fifty per cent so we

will reduce our formula accordingly and use two thirds of the values thus reducing the formula to the final form,

$$\text{H. P.} = .02822\, n \sqrt{p^5}\ \sqrt{\text{R.P.M.}}$$

In this last expression there are four variables and therefore it will be possible to plot it in a diagram of two steps as has been done in Fig. 10.

The strength allowed for steel gears is just two and one-half times that allowed for cast iron, therefore this element may be covered by making a permanent slide rule of a strip of log paper pasted along the left hand edge in such a location that the H.P. values of cast iron are multiplied by two and one-half. In like manner the direct reading of face corresponding to any pitch is made possible by the strip pasted along the extreme right edge in such position as to multiply the pitch by three.

As diametral pitch is π x reciprocal of circular pitch, this may be covered by the intermediate inverted strip along the right edge so placed that π is in line with 1″ pitch and thus the corresponding diametral pitch and face read directly.

Bevel gears may also be read from the diagram by increasing the initial H.P. fifty per cent. This is on the common assumption that they are two-thirds as strong as spur gears.

One lame point in this treatment is indicated by the heavy dotted line crossing the first step of the diagram. Intersections to the right of that line may give speeds below 100 ft. per min. and therefore weak gears according to Lewis. The reason for this is seen when considering the fact that Fig. 11 gives a constantly increasing stress value for all reductions of speed where Lewis makes no increase below 100 f. p. m. A safe correction adds 10 per cent to the initial H. P., for each 10 feet reduction in speed below 100 feet per minute. It should be noted that all diagrams of the preceding class are reversible for finding other elements of the problem or studying capacities, etc., of existing equipments.

A further discussion of this subject may be found in the February, 1911, issue of the Journal of the Western Society of Engineers. In that paper special slide rules and other types of diagrams are treated quite fully.

The Clay Drain Tile Industry in Iowa

C. B. Platt*

During the year 1911 more drain tile were manufactured in Iowa than in any other state in the Union. This appears to be more of a statement when it is observed that the nearest competitor for place, Indiana, produced tile to the value of $2,006,-803 and that Iowa factories produced tile exceeding Indiana's value by practically a half million of dollars. It is also interesting to note that Iowa's production of drain tile constituted over 28 per cent of the total production of the United States. The total valuation of Iowa's production of tile in 1911 was less than that of 1910 and it is probable that the total valuation of 1912 will be considerably less than that of 1911. This falling off is not, of course, due to lowered producing capacities. On the contrary, there has been great development in this respect during the past few years and even a greater capacity will be added during the year 1912.

Reduced to miles, Iowa's tile production under present capacities, would be practically 25,000 miles per year, and since a remarkably conservative estimate of the number of miles of tile that will be required to partially drain (that is to remove water of saturation) the comparatively flat lands of Iowa, is placed at 1,000,000, there appears to be no very good reason why the past few dry seasons should witness a falling off in production. It is probably true that a large percentage of the tile used in 1911 were what were demanded by main lines of district drainage systems where tile of large diameters are used, and that the use of tile in farm drainage systems fell 25% below the consumption from the same source during 1909.

For many years Ohio lead the states in the production of drain tile and while the production of that state did not equal present day production in Iowa, the number of plants engaged in the industry outnumbered the number now in Iowa by perhaps three to one.

*Secretary Western Tile Drainage Bureau.

This is accounted for by the fact that there is a wider distribution of suitable clays in Ohio than there is in Iowa.

Manufacturers of tile generally attempt no further classification of clays than the division of soft clays, or such as are readily worked by roll crushers, and hard clays or shales which are only successfully reduced by a drypan or hammer pulverizers.

So-called soft clays are not common in Iowa. That is, our soft clays are not the best for drain tile. There is no limit, practically, to the deposits of jointy and sandy yellow clays, but for various reasons, such as poor drying properties, lime pebbles, etc., these clays can not be utilized excepting in instances and then when small capacities are employed. Eastern central Iowa, the first field of drainage operations, has an abundance of the soft clays and it was over these fields that the first development in the tile industry took place. These clays are comparatively free from lime, but they are short, do not mold easily and must be dried very slowly. For these reasons they offered no inducement for large capacity plants and the greater development took place in the shale fields.

In the vicinity of Mason City is a deposit of what is termed "shale-clay," a clay of a variety which works readily in reduction, through roll crushers. This clay pugs readily, flows in the dies freely, dries under hot blast without damage from checking and does not readily lose its shape in the process of burning. It is accessible and is located in the middle of a great area demanding drainage. It follows that at Mason City the greatest development in the industry has taken place, and it is today the greatest tile producing point in the world.

The hard clays or shales are distributed along the banks of the Des Moines and Raccoon rivers, Webster County being the northern limit of occurrence, and in two counties bordering on the Missouri and the Mississippi. There are other small outcrops of shale fields at various points, all of which have been worked more or less.

Generally, these deposits have a considerable overburden, ranging from eighteen inches to as many feet, which must be wasted before the shales are exposed. In a few instances this is

removed with hydraulic stripping equipments, but in the majority of cases it is an item of considerable moment in the cost of production.

Since the shale deposits are not distributed over a greater territory, the consuming field must be supplied by plants from a considerable distance and it follows that the plants supplying the demand must take care of large territories and must, consequently, have large capacities. To manufacture tile in large quantities from shale requires a large investment of capital. The mining and reduction of the shales require heavy machinery and the tempering of the ground shales requires much power. From this point on shales are easily handled. That is, they generally dry without difficulty and have a wide range between the vitrification and melting points and so offer no serious difficulty in burning, and can, as a rule be vitrified.

The development of the tile industry in the shale fields has been more in numbers of plants than in multiplied capacities

Possibly more have started than conditions, as applied through a number of years, would warrant. It is undoubtedly true that some shales are better than others and that it is not always safe to use all of a bank of shale from drainage level to cap rock or stripping, in the manufacture of tile, if STRICTLY HIGH QUALITY is desired.

A great deal of money has been invested in this field and as the development has been rapid, in order to get in the market before the demand was filled, much money has been wasted in the wrong equipment of one kind and another. In fact this money has been invested to so many disadvantages as to make improvements in methods and equipments imperative and there has grown up a modern plan, a scientific application of mechanics and business to economic questions, which must force a practical reinvestment. Manufacturing and marketing science must be mixed in the same vessel. The days of "natural" advantages, obtained by a favored few in the way of freight rates, having passed, and the manufacturers finding themselves crowded into a common manufacturing territory, all delivering on about the same average freight rate to a certain extent of the field, find themselves confronted with real questions of com-

petition. 1912 has demonstrated that low prices will not make demand. What next? The question must be taken to the consumer, or the rain maker. If it is taken to the consumer, he must be shown that no other material, commercially possible, is the equal of clay or shale for drain tile. The consumer is being educated by the state, and is learning this definition. Drain Tile: "A pipe; perfect in shape, light in weight, extremely hard and of great strength. Made from clay and burned to vitrifiaction." This is a definition easily learned and easily applied to judge the finished product, consequently a safe one to follow in selecting drain tile. Now there are other things, and they should in this day be counted in as items pertaining to the manufacture of drain tile, which the consumer of tile should know as well as this definition. One is that silk and calico are not grown on the same plant and that one requires more time and effort to produce than the other and that cheap price is not a measure of high grade quality. There should be no uncertainty about investments in the development of the clay tile industry in Iowa. Given the required skill in employees, the proper installation and a regular grade of raw material, it is no secret process to figure out the cost per ton of finished product. That is, the minimum cost, to which a rather wide percentage should be added for contingencies, more or less wide, according to the available supply of labor and the equipment provided to meet the conditions of stormy weather.

In Iowa it costs a certain number of cents per hundred pounds to transport tile over a given number of miles in any direction from any point. There need be no uncertainty regarding the radius of the circle surrounding any clay deposit, containing for such deposit a positive advantage in delivery cost, nor the length of the radius which will carry it into dangerous ground in which to compete in price during times of slack demand. When this line is unduly lengthened, unless quality is the competing point, it means one of two things: loss to the producer or loss to the industry through lowered quality.

Iowa tile manufacturers are appreciating this. They are

manufacturing with the idea of knowing cost and are recognizing the necessity of this modern manufacturing safeguard. They know that quality must be maintained and that to do so a minimum profit margin cannot be passed which will enable them to replace, piece by piece, the equipment of their plant, to such an extent that the total in ten years will amount to as much as the original cost of installation.

Iowa manufacturers have handled an industry which has remained at a standstill for centuries as far as scientific development is concerned, through a period of change in methods which has been most rapid in its advance. They have made extensive investments within the past ten years which have in that time become out of date and they have started in on the greater work ahead with a determination to place their industry in the front ranks of modern day manufacture.

They are no longer satisfied with perishable construction in their plants. They feel keenly that their industry has been wasteful and they are setting about applying the remedy. They are mining their clays with steam shovels, transporting them to the grinding machinery by electricity; operating their machinery throughout by electricity; drying their product by waste heat; burning their ware in continuous kilns and are handling their product throughout with as little of the direct touch of human hands as they find possible.

Although great progress has been made, even greater progress is sure to be made. All are not as yet convinced that electricity for power and continuous kilns to conserve heat as profitable in practice as theory but the tendency is in that direction.

Several plants are electrically driven but mostly in plants of small capacity. One large plant at Boone has recently discontinued the use of steam and uses electricity for driving all its machinery.

A large capacity clay tile plant is now being constructed at Ft. Dodge by the Vincents. Its builders are not limiting expenditure nor sparing time in their determination to make

this plant modern in every respect. Engineering skill worked the basic questions before work was started. The shale field was prospected and examined and the best mixtures of strata determined before the plan of working the deposit was determined upon. The clay handling equipment was designed to handle the shale to the storage bins with the minimum expenditure of labor and power. The principles of real economy, only obtainable by the careful expenditure of capital in large amounts to meet carefully studied out questions of economy of construction and operation, have applied from the first. The idea, held to firmly, has been to establish the plant so as to make possible maintained capacities, equal to a large percentage of maximum capacity rating of the equipment. The builders have also shown a determination to secure the maximum of space economy, reducing to an approximate minimum distances of travel and motions in handling the product, and to conserve power and heat. All machinery will be electrically driven. A continuous kiln, fired with oil will be the instrument of conservation of heat in burning. Electrically driven fans will induce draft and draw off waste heat in quantities available, for use in portions of the dryer arranged to utilize same. Oil fuel will be used to heat the lower series of tunnels and radiated heat from this tier together with waste heat from the kilns or supplied heat from the oil furnaces, will supply the necessary heat for the second tier of tunnels and the waste from these two tiers of track or car dryers will supply heat for drying the larger tile set on slatted floor constituting the third tier of the dryer. Over the continuous kiln will be another floor which will utilize for drying purposes the radiated heat from the kiln.

At Mason City, the Mason City Brick & Tile Co., operating four large tile plants, have recently installed electrically driven grinding machinery in a central clay preparation plant, which will supply clay for all four plants. This is an economic move which will not only save labor but insure a regular supuly of clay and a more even grade of prodnct, which will result in added capacity for each plant.

THE IOWA ENGINEER

Published Monthly During the College Year by the Students of the Division of Engineering, Iowa State College

Official Organ of the Iowa Brick and Tile Association and of the Iowa Association of Cement Users.

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Statement of the "Iowa Engineer

In accordence with the postal laws and regulations, the names, positions and addresses of those in charge are as follows: Editor, Paul Clapp, Ames Iowa; Business Manager, F. A. Mosher, Ames, Iowa; Publishers, King Printing Co., Ames, Iowa. There are no owners or stockholders. The magazine is the offecial organ of the Engineering Society of the Iowa State College, and no salaries are paid to those who serve as members of the staff.

Sworn to and subscribe before me this 4th. day of October, 1912.

W. M. Greeley

Notary Public

EDITORIAL

As the publication of the engineering students of the college, we believe that "The Iowa Engineer" should keep pace with the growth of the Engineering Division. Further than this, we are of the opinion that the magazine should anticipate the growth of the division, and expand itself to such a measure as to be a worthy representative. All indications point to an exceptional increase in the engineering school during the next few years. With all engineering in the state concentrated at Ames; with engineering extension in operation, and with Iowa's great industrial educational system centered here, no one can predict the future of our Engineering Division.

We are sure that all engineering alumni and students will back us in the improvements we are about to make in "The Iowa Engineer." Commencing with the December issue the size of the page will be increased to that used by the technical publications of the Eastern universities. A corresponding increase will be made in the number of articles appearing each month, and the general quality of the publication will be improved. To make these changes we are assuming a certain financial risk, that can only be met by the support of boosters for Engineering at Ames. You can be one of these boosters by becoming a subscriber for the magazine, or by paying up your old subscription and forwarding an advance. We know you want "The Iowa Engineer" to be a magazine of which the engineers can be proud. Help us make it so.

Mr. Gordon F. Dodge, the author of the article on Graphical Equations in this issue numbers among those alumni of the engineering division who have made a signal success in their profession. Mr. Dodge took his degree B. M. E. in 1898 and that of M. E. in 1910. He is a member of the Western Society of Engineers, and until recently was chief draftsman of the Robbins Conveying Belt Company, New York City. At present he is Building engineer with the Stone and Weber Engineering Corporation, who are doing the overhead work on the Keokuk Power Project.

Among the questions which have arisen as a result of the decision of the State Board of Education to consolidate all engineering at Ames, is that which deals with the requirements of an engineering education. It is recognized that the competent engineer must receive an education board enough to enable him to occupy executive and administrative positions. He must also be in touch with the large social problems of the day and understand the human element that enters into the production of a commodity. The courses in Engineering given in the Iowa State College have kept pace with this idea. Economics, History, Language, and English are all included on the list of required work, while a great number of kindred studies may be elected. A graduate of the engineering school is, therefore, far from being a narrow and extreme specialist. He is on the other hand, well fitted to deal with his problems from a high view point.

Mr. G. A. Wrightman, secretary of the Iowa State Manufacturers' Association addressed the Engineering Society on the subject "Industrial Iowa" at its October meeting. The fact that Mr. Wrightman has been one of the most active among those interested in developing the industrial educational system of the state made his appearance of double interest. He is closely in touch with the needs of the manufacturers of the state, and largely due to his efforts the Manufacturers' Association passed resolutions favoring the establishment of such courses in connestion with the engineering school at Ames. As a booster for Iowa, no one is the equal of Mr. Wrightman. Thoroughly convinced that a state with 6,000 manufacturing plants producing $335,000,000 worth of goods yearly offers great opportunities to the young engineer, he points out the advantages to them of going to work "right here in Iowa."

On September 23d, Dr. Raymond A. Pearson took his place as President of the Iowa State College. No loud demonstration nor impressive inaugural service marked his coming. Quietly he set his step in cadence with that of the great school he is to direct, and then forcibly and actively added his strength to its

efforts. President Pearson is a native of Indiana, but claims Iowa as his home for it was here that he spent his boyhood days. He graduated from the college of agriculture of Cornell University in 1894, and received his master's degree from the same institution in 1910. He was seven years assistant chief of the dairy division in the Department of Agriculture, and in 1908 was appointed Agricultural Commissioner for the state of New York.

President Raymond A. Pearson

Although especially trained in agricultural lines, President Pearson comes as one well fitted to oversee a large and growing engineering school. He has already evidenced his intentions of making Ames one of the best engineering schools by his earnest efforts in behalf of the new Engineering Extension plans.

"The Iowa Engineer" bespeaks for the alumni and students of the Engineering Division most hearty support to President Pearson in his work for a greater I. S. C.

Alumni Notes

M. J. Riggs, C. E., '83, is manager of the branch plant of the American Bridge Co., at Toledo, Ohio.

E. J. Nichols, C. E., '84, is now assistant engineer of the St. Louis Southwestern Railway Company. His headquarters are at Tyler, Texas.

John E. Dougherty, C. E., '84, is doing general engineering and construction work at Wichita, Kansas.

R. G. Rice, E. E., '93, who has been located in New York City for several years, recently moved to Hartford, Conn.

R. C. Anderson, M. E., '98, is with the Allis-Chalmers Co., at West Allis.

Frank M. Okey, C. E., '04, who was with the Department of Civil Engineering at the University of Illinois last year, recently resigned to accept a position as engineer of construction for the General Cement Gun Co., of Chicago. The company has just been organized with a large capital and its success is assured.

H. J. Brunnier, C. E., '04, maintains an office in the Monadnock Building, San Francisco, and is doing an exceptionaily large contracting business.

Edward C. Gersbach, C. E., '04, is superintendent of construction on the Hog Back Canal, Liberty, New Mexico.

C. L. Crawford, C. E., '05, was recently transferred from Mexico to London, England, by the S. Pearson Company in whose employ he has been since graduation.

C. H. Currie, C. E., '05, is city engineer at Webster City, Iowa.

W. B. Cole, Mn. E., '06, is with the Ohio Copper Company Concentrator at Lark, Utah.

A. C. Bullen, '10, is engaged on the construction of a waterworks plant at La Junta, Colorado.

Eddie McCoy, E. E., '11, formerly with the Peoples Light and Coke Company of Chicago, commenced work for the Peoples Light Company of Davenport the latter part of August.

C. H. Myers, M. E., '12, is employed by the Peoples Light Company at Davenport, Iowa.

Chas. J. Stahl, E. E., '07, is with the Korsmeyer Company of Lincoln, Neb.

E. E. Schenck, C. E., '09, is with the Bureau of Public Works at Manila, P. I.

George E. McCan, M. E., '09, holds the position of designer in the carriage department of the Packard Motor Car Company, Detroit, Mich.

L. N. Hintgen, C. E., '11, is with the city engineer of Sioux City, Iowa.

E. V. H. Brown, C. E., '11, has a successful engineering practice at Albert Lea, Minn.

Geo. B. Brush, E. E., '11, is still with the Westinghouse Electric Co., at Pittsburgh, Pa.

W. V. McCown, C. E., '12, is draftsman for an interurban company at Omaha, Neb.

Russell Furman, C. E., '12, is located at Lyons, Iowa.

R. F. Van Deventer, E. E., '08, who has been teaching in the manual training high school at Indianapolis, Ind., now has charge of the mechanical drawing courses in the High School at Evanston, Ill. His address is 1414 Elmwood Avenue, Evanston, Ill.

A. M. Blodgett, '76, is president of the Blodgett Construction Co., of Kansas City, Mo. This company constructed the great Galveston Causeway at a cost of $1,500,000.

Alfred Williams, C. E., '84, was recently elected president of the Ocean Shore Railroad Co., with offices in San Francisco.

Mike Adams, C. E., '10, was a visitor at the college at the time of the Grinnell football game. Mr. Adams has just returned to Iowa from the west where he has been doing engineering work.

Chas. A. Hobein, E. E., '03, has resigned as superintendent of Power Plants for the United Railways Company of St. Louis, effective November 1st, to accept a position as Electrical and Mechanical Engineering Advisor and Inspector for the Bond House of John Nickerson, Jr., St. Louis.

STUDENT

CONTENTS

Engineering Hall

THE IOWA ENGINEER

VOL. XIII | DECEMBER 1912 | NO. 3

Engineering Buildings and Equipment of the Iowa State College

ENGINEERING HALL

The rapid increase in the number of students enrolled, together with the development of the engineering work of the college during the late nineties, made it necessary for the state to provide additional buildings and equipment. Complete plans for a building large enough to provide room for all the engineering departments were prepared and submitted to the 28th General Assembly. This was a critical period in the history of the institution. Acceptance of the plans prepared would indicate the adoption by the state of a new policy toward this college, and make it possible to build up at Ames one of the great engineering schools of the country.

The plans called for a stone, brick and concrete building, fireproof throughout, with its offices, class rooms and laboratories fitted with all the conveniences necessary for carrying on high grade professional engineering work.

The Legislature, after a careful investigation of the engineering work done at Ames and the advantages of locating a school of professional engineering at this point, adopted the plans without modification and appropriated funds for the building and its equipment.

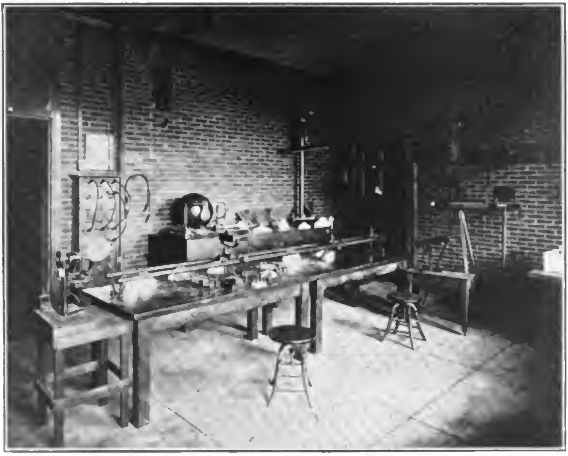
The contract for the building was placed and the work started in 1900. The building completed and furnished represents an investment of $220,000.00.

At its completion the building was the best in the country devoted to engineering work, and even now after twelve years it is exceeded in size and cost by only two or three and in quality and convenience by none.

This building was so satisfactory in appearance, design and operation that the Board of Trustees adopted the same general type of construction for Central and Agricultural Halls. The silent influence exerted by the beautiful architecture and solid

Mining Engineering Seminar Room

rooms, is used by the department of physics for class, laboratory and special research work. In the north end of the second floor are located the offices, class and part of the designing rooms of the mechanical engineering department. The south end of this floor is given up to the offices and general laboratory of the departments of physics and illuminating engineering and electrical engineering. The general assembly room with a seating capacity of 270 is located in the circle room opening off this floor. The north end of the third floor is occupied by the department of mining engineering and geology for its offices, class and seminar rooms and geological museum. At the south end of the same



Photometry Room—Illuminating Engineering

floor are the offices, class and part of the designing rooms of the civil engineering department. In the circle is the engineering library and reading rooms with 6,000 volumes and complete files of all engineering journals and papers. The center and north end of the fourth floor is used by the mechanical engineering department for office and drawing room work of the freshmen and sophomore classes. The south end of the floor is used by the civil engineering department for its railway engineering designing and drafting room work. Photographic and blue print rooms are also located on this floor.

Mechanical Engineering Drawing Room

A Corner of the Cabinet Room—Physics Department

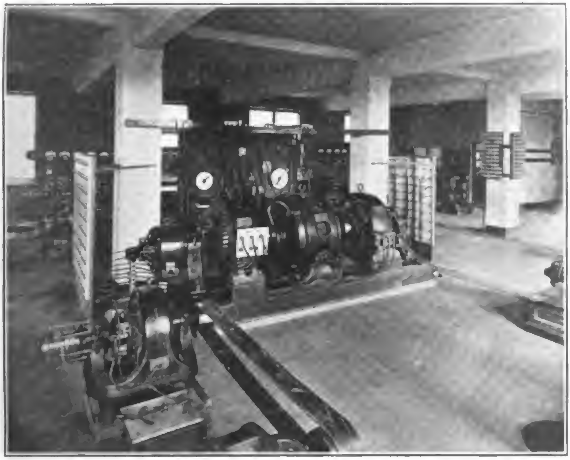
After having used the building for nearly twelve years, the engineering faculty is of the opinion that there are but a few minor changes that could be made to improve it for the service for which it was planned.

Central Building—where courses in English, Languages, History, Mathematics, Economics, etc. are taught

Engineering Annex and Ceramics Building

ENGINEERING ANNEX AND CERAMICS BUILDING

This building was erected in 1909 to relieve the congestion in Engineering Hall and to provide quarters for work in Ceramics and Industrial Chemistry. It has three stories and a total floor space of 43,000 square feet, of which 39,000 square feet is useful working space. The first floor at the north end is used by the Civil Engineering Department for work in surveying. The instrument room here located is equipped with 50 steel lockers,



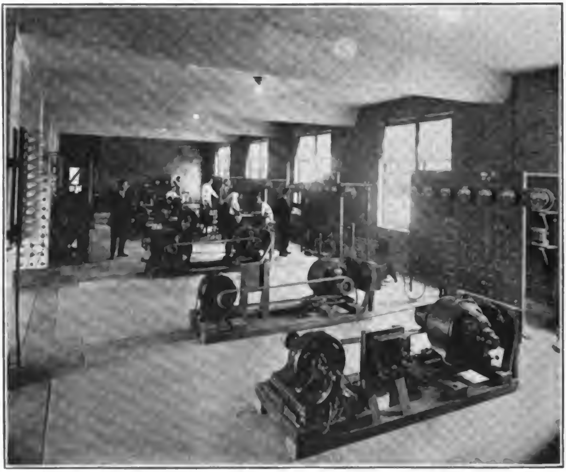
Substation--Electrical Engineering Laboratory

each locker containing a set of field instruments. The value of this equipment is $7,900.00.

On the first floor, the middle third of the building is occupied by the dynamo laboratory of the Electrical Engineering Department. The power for this laboratory is supplied by a $3,000 substation consisting of a 60 K. W. direct current generator and a 50 K. V. A. alternator driven by a 100 H. P. Induction motor which takes its power from the College Power Station. The laboratory contains some 25 motors and generators grouped in pairs and associated with individual switchboards on which are mounted the necessary meters, circuit breakers, rheostats and switches.

Transformers ranging in capacity from 3 to 10 K. W., rotory converters, measuring instruments of every type and a complete set of auxilliary apparatus are in regular use for testing purposes. The total value of the equipment in the dynamo laboratory is $17,400.

The South End and Wing of the building is used by the Department of Mining, Ceramics and Industrial Chemistry and by the Engineering Experiment Station. The equipment used for Mining Engineering is located on the first floor at the east end.



Testing Motors and Generators—Dynamo Laboratory

It includes a three compartment jig large enough for washing coal in ton lots, and an entire system of ore dressing machinery. A number of hand and power grinding machines are utilized in crushing and pulverizing the ores to be assayed, smelted or analyzed. Smelting of the ores is done in an especially equipped furnace room, which contains five direct fired muffle furnaces in addition to the several gas and wind furnaces.

In the wing, the central portion of the first floor is occupied by the main clay working room, kiln room and testing laboratories of the Department of Ceramics. The clay working room contains a 16-inch Patterson Vertical pugmill, filter presses, a

double plunger, a series of porcelain ball mills, a Patterson clay working outfit and an American jolly with Knowles pull-down. This equipment together with that in the adjacent dry grinding room is used to prepare the various clays for burning. The kiln room proper contains a coal fired, down draft kiln having a kiln chamber of 2x2x2 feet and an ore fired pottery muffle furnace for special work. Provisions for the physical testing of clays, cement and other ceramic raw materials are made in a testing

Studying Commercial Processes—Industrial Chemistry

room fitted with a steam dryer and other special equipment.

The remainder of the space on the first floor of the wing is utilized by the department of Industrial Chemistry. A complete set of crushers, mixers, stills, filter presses and retorts are here employed for carrying out the different commercial processes. These include those used in a study of the methods of manufacture of soap, paints, varnishes, chemicals and other products of the chemical industry.

The second floor of the Annex proper is occupied by offices, class rooms, and three drafting rooms; two for civil engineers and one for electrical engineers.

On the second floor of the Wing are located rooms for py-

Civil Engineers Making Calculations from Field Surveys

Testing Clay Products—Ceramics Engineering

rometry, gas, fuel and water analysis besides laboratories for the chemical section of the Engineering Experiment Station. The room for pyrometry and gas fuel testing is directly over the kiln room and is therefore convenient for the testing and sampling of flue gases. The equipment includes an improved Elliott apparatus for gas analysis, Parr calorimeter for solid fuels, several electric furnaces, and electrical, optical, and metallic pyrometers. The Chemical Section of the Engineering Experiment station is thoroughly equipped with all apparatus necessary for carrying on the chemical work of the Station, which consists of much research work in addition to the large number of water and fuel analyses made each year.

Specimens of Pottery made by Ceramics Students

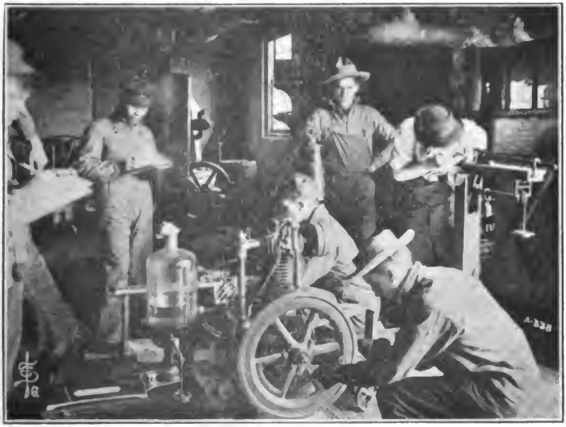
Agricultural Engineering Building and Annex

AGRICULTURAL ENGINEERING HALL

Agricultural Engineering Hall is a brick and stone building 64 feet by 104 feet in size, of which the two lower floors are devoted exclusively to the use of the Agricultural Engineering Department.

In this building are located the offices of the department, several class rooms, two drawing rooms, a carpenter shop, three laboratories and a central tool, supply and instrument room for the department.

The carpenter shop has benches and tool sets for thirty students and is provided with a power cross cut saw, a rip saw ,a planer, two speed lathes and miscellaneous tool equipment. The



Making a Test of a Gasoline Engine

steam engine laboratory contains a simple 20 horse power engine and a 35 horse power compound reversing engine. Steam is supplied from the college heating plant and boiler practice is obtained from steam tractors. The cement laboratory contains bins for materials, molds, forms, an improved Fairbanks cement testing machine and smaller apparatus. The pump laboratory contains an assortment of pumps, tanks, cylinders, spraying devices and other water supply apparatus. For instruction in surveying there are provided two transits, fourteen levels and the necessary rods, flag poles, chains, etc.

A Practical Test of an Oil Tractor and Gang Plow

Agricultural Engineers Testing Steam Tractor

AGRICULTURAL ENGINEERING ANNEX.

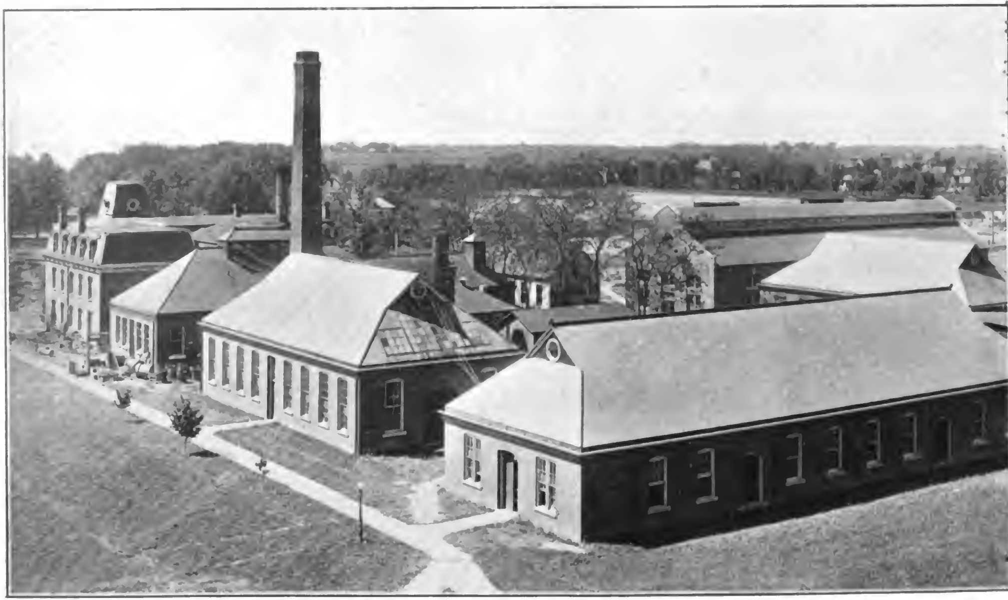
Agricultural Engineering Annex is a fire proof building built of reinforced concrete and pressed brick, 60 feet by 100 feet in size and four stories high. It is devoted exclusively to the use of the Agricultural Engineering Department and is connected with Agricultural Engineering Hall on the ground and first floors.

The farm machinery laboratories are located on the ground and first floors. Each of these floors has a large balcony entirely surrounding each room, which provision increases the floor space over one-half. Here is to be found a large assortment of the best modern farm machinery obtainable, consisting of traction engines, gasoline tractors, and one or more samples of almost every kind of important lines of field and power machines used on the farm. For testing draft adjustment and quality of work, special apparatus is provided, including a Kohlbush direct reading dynamometer, a Stone and Polikeit recording traction dynamometer, a recording and integrating dynamometer designed by the Department, and a special chain recording transmission dynamometer of 25 horse power capacity.

For instruction in the internal combustion engines, 9 modern gasoline engines are provided, nearly every one representing a different type of construction. In addition, the Department owns various brakes, indicators and other appliances used in engine testing.

The forge shop is equipped with 30 Buffalo and Sturdevant down draft forges, and individual tool sets together with a press drill and grinder and a complete set of special tools.

It is considered that the department has the most complete equipment of any school teaching agricultural engineering. Additions are continually being made as improved farm machinery is placed on the market.



The Engineering Shops

THE SHOPS OF THE ENGINEERING DIVISION

The one common objection that one hears expressed by the employers of technical graduates is that so many of them are lacking in practical training. Most of them are well grounded in the principles involved but have not had the opportunity to put those principles to a practical test. The man who has had the theoretical training only is a one-sided man as well as he who has had only the practical side. What the world is demanding is well rounded men so trained in their professions that they are able to undertake and carry through successfully, without friction and delay, the work that they are given to do.

The Iowa State College of Agriculture and Mechanic Arts is striving to turn out such men, and with this end in view has paid particular attention to the shop equipment in order that "Science with Practice" might be a fact as well as a motto on the College Seal.

The shops are located in a group just southwest of, and in close proximity to, Engineering Hall and the various laboratories of the Engineering Division. The group is composed of four buildings; Pattern Shop, Foundry, Forge Shop, and Machine Shop. All are fully equipped, and with their equipment, they represent a total outlay of over $52,000.00. Students in mechanical engineering are required to spend two half days per week in these shops for a period of three and one-half years. Those taking other engineering courses, while not required to spend so much time, are given such work as is necessary to make them familiar with shop practice in their respective lines.

The work consists of graded exercises calculated to familiarize the student with tools and materials used. These exercises are later supplemented by work on machines or machine parts, which the student sees put to actual use. The object of the shop work is not to teach the trades, but to familiarize the student with the tools, materials and difficulties of shop practice, and to give him such experience as will better fit him for his professional career.

PATTERN SHOP

The Pattern Shop is a one story brick building one hundred and twenty feet long and forty feet wide. It is a completely equipped wood working shop with all the tools necessary for the making of wood patterns. Arranged around the outside walls near the windows are benches and lockers which will accomodate thirty students at one time. An individual locker, containing a set of tools, is assigned to each student who is then held responsible for the tools until the end of the semester. Special tools which are used only occasionally are kept in a tool room screen-

ed off in the center of the shop and may be checked out when needed. A spacious attic furnishes storage for lumber. The remainder of the equipment consists of a universal buzz saw, jig saw, core box machine, sander, grindstone, two pattern makers'

Pattern Shop

lathes and fifteen turning lathes. Power for the building is furnished by a twenty horse power electric motor. A fire proof room in the west end gives storage for a large number of the finished patterns and core boxes. In this shop the student is given drawings of machine parts from which he is required to make patterns for use in the foundry.

FOUNDRY

The foundry is a one story brick building 38x78 feet in size, and with the equipment contained therein represents an expenditure of $6,000. The molten metal for making iron castings is poured from a 30 inch cupola, the blast for which is furnished by an electrically driven Connersville blower. A brass and aluminum furnace furnishes facilities for making castings of these metals. Near the cupola are the core benches and core oven. The mould-

ing equipment includes several moulding machines, 24 sets of moulders' tools, and a large supply of cast iron, steel and wooden flasks. A traveling crane supported from the steel roof structure serves the whole floor for handling heavy ladles and cast-

The Foundry

ings. At the rear of the building are storage sheds for coke, pig iron, and other charging materials. The patterns, after being brought to the foundry from the pattern shop, are used in making molds in either dry sand or loam. The student thus has an opportunity to see his work tested by practical application.

FORGE SHOP

The forge or blacksmith shop is a one story brick building of the same size as the foundry. An additional wing on the rear is used as an office and stock room. In this shop there are thirty forges, an oil burning annealing and tempering furnace, drill press, screen press, power hammer, punch and shear, grindstone, emery wheel, and complete equipment of small tools. Blast for the forge is furnished by a pressure blower and an exhaust fan

draws the smoke from the forges into the exhaust flues.

The work in the shop, which consists of making different machine parts, welding iron and steel, and forging and tempering various kinds of hand and machine tools, is given with

A Corner of the Forge Shop

the idea of making the student familiar with the methods and with the cost of this type of construction work.

MACHINE SHOP

The Machine Shop, the largest of the shops, was built last at a cost of $18,000.00 without equipment. It is a brick building 150 feet long by 45 feet wide and has a main floor and gallery. At one end of the main floor is located the toilet and locker room, a reading room, and an office. A room for special small tools is screened off near the middle of the shop and has a storeroom above. Besides the large assortment of small tools the shop contains one fifty-one inch electric drive vertical boring mill, a twenty-four by twenty-four inch planer, a twelve by forty-eight inch Universal milling machine, a six by thirty inch milling machine, a Universal grinding machine, a shaper, two drill presses,

two emery grinders, a polishing wheel, a power hack saw, a cut-off machine, sixteen large engine lathes three speed lathes, and a large electric motor. This equipment represents an expenditure of over $10,000.00. Here the student takes the rough machine

Machine Shop

parts as they come from the forge shop and foundry and machines them to the correct size and finish. Considerable time is also spent in making and tempering, or case hardening small tools such as milling cutters, reamers, taps, dies, drills, etc., and the making and using of jigs and templates. A course in pipe fitting is also given in this shop. The student is required to build up various shapes out of pipe and fittings, to set up sectional radiators and pipe them correctly, to jute and lead a cast iron pipe joint and to do other similar exercises.

The instructors in all of the shops are practical men, experts in their respective lines, and have been chosen because of their experience gained in large shops of this and othr countries.

Structural and Hydraulic Laboratory

STRUCTURAL AND HYDRAULIC LABORATORY.

Up to the time when Engineering Hall was made available for use, the larger portion of the division of engineering was quartered in the building now used primarily for the testing of materials and experimental hydraulics. This building is now known as the Structural and Hydraulic Laboratorq. The main part of the building consists of a basement and three stories each 30 feet by 90 feet in size. A wing of three stories, each 25 by 30 feet, extends off to one side. The walls are of brick and the remainder of the building, except the roof, is of fireproof construction.

Cement Testing Laboratory

The work of the Engineering Experiment Station involving the commercial testing of building materials is provided for in this building. A part of the laboratory work of the Mechanical Engineering Department in steam and gas engines has been given in this building for a number of years. On its completion the equipment for this work will be moved to the new steam and gas laboratory for which the contract has already been let. At that time it will be possible to expand the structural and hydraulic laboratories so as to make use of the entire building.

The instructional and alboratory work is carried on so as to give the students a knowledge of the testing of the materials of construction, and also of their manufacturfe, properties and uses. To this end laboratory and lecture courses supplement each

other. A lecture room is provided with a stereoptican, for the purpose of illustrating the manufacture and use of the various materials.

The laboratory for the study of cement and its uses is equipped with three tensile testing machines of the shot type, one 60,000 pound hydraulic press, a complete outfit of molds, sieves, specific gravity apparatus, etc., oven, boiler, stone top mixing tables, running water storage tanks, and in fact all the equipment necessary for the customary tests of cement and sand as well as special apparatus used at various times for research work. In con-

A Corner of the Materials Testing Laboratory

nection with this laboratory are three machines of the "Ames" type for testing drain tileand sewer pipe.

For the study of metals, timber, brick, stone and other materials, the laboratory contains the following machines: Four Universal testing machines of 20,000, 50,000, 60,000 and 100,000 pound capacity; two transverse testing machines of 10,000 and 100,000 pounds capacity; one wire testing machine of 20,000 pounds capacity; one torsion machine; one brick rattler old standard, and one brick rattler new standard. In addition to these testing machines, the laboratory has a numebr of extenso-

meters and measuring devices, together with all the necessary instruments and tools for accurate and scientific testing.

The development along all lines of hydraulic engineering during the last decade has been remarkably rapid. Perfection in electric transmission of energy has made possible the development of commercial centers from sources of natural hydraulic power formerly inaccessible. The growth of population and the corresponding rapid increase in land values has directed attention to the advantages to be obtained through drainage and irrigation. The increase in population has made the questions of pure water supplies, municipal drainage, sewage disposal,

Hydraulic Laboratory

river improvements and inland navigation of much importace. These factors, as well as many others, have brought to the attention of engineers, especially, the necessity of a thorough knowledge of the principles of hydraulics, and a more exact study of hydraulic phenomena.

It is this increased demand for special information and training in hydraulics that has led the Iowa State College to lay plans for developing a first class hydraulic laboratorq.

In carrying on the work in experimental hydraulics, it has been endeavored to give the student not only an opportunity to verify theory by experiment, but also to give him a working knowledge of the various hydraulic machines and accessories.

Morrill and Central Halls

The hydraulic equipment consists of various measuring tanks and scales for weir and orifice experiments; numerous pressure gages, water meters, thermometers, etc., centrifugal pumps, rotary pump, triplex pump, hydraulic ram, reaction and impulse water wheels, electric motors with switchboard and controller, pipe for friction tests, gage tester, and the necessary equipment of tools, instruments and fittings to arrange for special tests and investigations. A special feature of the hydraulic laboratory is a forty foot steel stand pipe which is used for reservoir, supply and pressure purposes. Water is supplied to this stand pipe by means of suitable pumps operating at such head and capacity as may be desired. The laboratory obtains its water supply from the college mains and requires only a comparatively small amount for its operation, as a pump reservoir is provided from which the pumps take their supply. The standpipe is fitted so that it can be made into an air tank, making possible experiments requiring high heads and a wide range of operating conditions. This system of using pumps and air tanks, so as to obtain a variable water supply and head, conforms to the practice in nearly all of the first class hydraulic laboratories of the country.

The cost of the water used and the cost of pumping in the laboratory is very low, as there is no expense except during the time when the water is actually used. Should a larger volume of water be required by future demands, it can easily be supplied by the installation of extra pumping units and at comparatively small expense.

STEAM AND GAS ENGINE LABORATORY.

Ground has been broken for a new Steam and Gas Engine Laboratory to be completed and ready for occupancy by September 1, 1913. The building is to be of brick; the main part will be 55 by 120 feet with a wing 55 by 45 feet, off which will be built a smoke stack 128 feet in height. The east 30 feet of the building

proper will be full two stories high. The balance of this part together with the wing will be one story in height and of the main floor and balcony type. Fireproof construction throughout is to be secured by the use of concrete floors, steel columns and roof trusses, and cement tile roofing. The total floor space will be 10,400 square feet of which 4,000 sq. feet. will be in the balcony.

A basement in one corner of the building will contain locker, toilet, and storage rooms. All steam and water pipes are to be carried through the entire length of the main building and wing in a six by ten foot tunnel.

On the ground floor of the two story portion will be located the office and instrument rooms and a room for testing materials of construction. The equipment for the latter will consist of a

Steam and Gas Engine Laboratory

2,200 foot pound Olsen torsion machine, a 50,000 lb. Olsen Universal machine, a 100,000 lb. autographic testing machine and a 20,000 lb. transverse testing machine.

The second story will be divided into three rooms to be used for lecture, report, and class room work. The main room of the laboratory building will be 55 by 95 feet. In it will be installed the various steam, gas, gasoline, and oil engines as well as the steam pumps. The above equipment will consist of a 50 horse power Fairbanks-Morse suction producer gas engine, an 8 horse power Mietz and Wiess oil engine, several gasoline engines of various makes and sizes, a 20 horse power Corliss steam engine, various types of high speed steam engines, and an Ingersoll Rand cross compound two stage air compressor. All steam engines

will be arranged to run condensing or non-condensing, and will be available at any time for indicator practice, valve setting, governor regulation or efficiency tests.

The balcony is to be fifteen feet wide, will extend entirely around the main room and part of the boiler room, and will support two glass enclosed rooms each 12 by 28 feet in size. One of these rooms will be used for gas, coal and oil analysis, the other as an apparatus room. The balcony floor will be equipped with apparatus for the calibration of guages and the testing of injectors and pulsometers of various kinds. Small gas and gasoline engines of both the two cycsle and four cycle type will be mounted on this floor, along with different types of carburetors and magnetos.

The wing will be used for a boiler and gas producer room. It will contain a 50 horse power gas producer, an Ideal house heating boiler of 1,350 sq. ft. capacity, and a 150 horse power boiler with a smokeless furnace of standard type and a separately fired superheater.

THE WIRELESS STATION

The Iowa State College radio telegraphic station is purely for experimental purposes, designed to enable students and instructors to put theories to the test of actual use. The various parts, particularly the aerial, have been designed so as to be readily adaptable to use with practically all the various systems of sending and receiving. The fine equipment of precision instruments and machines in the college laboratories and shops makes possible the construction of almost every type of instrument or apparatus such as tuners, detectors, fixed or variable condensors, hot wire ammeters, etc., that may be needed.

The aerial or antenne consists of four phosphor-bronze stranded wires 260 feet long and spaced four feet apart. The insulation is secured by the use of eight hard rubber rods one inch in diameter and two feet long. The upper end is 160 feet above ground and the lower end at present about 70 feet. The aerial extends east and west with the vertical connecting wires attached at the east end, making it directive east and west for receiving and for sending. All parts of the aerial are readily accessible making it possible by changing the connections to make the system equally sensitive in all directions.

The sending apparatus consists of 12 standard navy type copper plated Leyden jars, a shop made helix of a few turns of heavy copper, a zinc spark gap also shop made, a 50 ampere key, and a 2 K. W. high tension 60 cycle transformer in addition to switches and other minor auxiliary devices. A new model 1 K. W. 11,000 volt Thordarson transformer is also available.

Various kinds of detectors have been used, most of them shop made and several of them very sensitive and satisfactory. A pair of 4,000 ohm head-band type receivers, as well as several others of lower resistance, are in use.

A portable receiving station small and light enough to be readily carried about in the hand, made in the college shops, has been used to study screening effects caused by various college buildings and by the steel water tank and tower. This set has

The Wireless Station

proved very sensitive and has given some astonishingly good results.

A set of wireless telephone sending apparatus has been designed and is now under construction here. It is hoped soon to have this interesting branch of wireless communication ready for testing and use at the college.

Little has been done by way of getting into communication with distant stations, though this might easily be accomplished. Almost any night it is possible by "listening in" to "pick up" messages from various distant stations, and some stations as far away as the Atlantic coast have often been distinctly heard to send messages and to sign their call letters.

The College Heating and Power Plant

POWER PLANT AND AUXILIARY EQUIPMENT.

To furnish power, light, heat, and water and to provide a sufficient sewerage system for a group of buildings as large as center at and near the college, requires a Central Power Plant and an Auxiliary equipment equal to that of an average city. The machinery and apparatus installed at the college and in daily use for these purposes is constantly being used by the students in engineering for experimental work. An excellent opportunity is offered thereby for running tests under actual operating conditions; for making studies of valuation; and for calculating the

The Boiler Room

cost of service to the producer. Such studies bring the engineering student into real contact with the very problems he will meet on graduation, and enable him to study out the correct solutions. For these reasons, the Power Plant and Auxiliary apparatus are to be considered as one of the most valuable parts of the engineering equipment.

CENTRAL POWER STATION.

The Central Power Station is the center from which all power is delivered. Here are housed the boilers; the electrical generators; the air compressor; water pumps; and central valves for heating mains. Coal to be used in the big boilers is unloaded

The Dynamo and Engine Room

from dump bottom cars directly into a track hopper. From this hopper, runs an apron conveyor which conveys the coal through a crusher if lump coal is being used, if not the crusher jaws are opened and the coal passes through this opening into the peck conveyors. It then runs along in the basement to the end of the building where it elevates into the bins above. These bins hold 375 tons of storage coal. The same carriers take the ashes from the boiler furnaces and elevate them to a position near the roof of the building, where they are discharged into a screw conveyor and carried to the ash bin. This bin holds a car of ashes and empties into cars below by pulling a handle on the outside of the building.

In the boiler room, there are three batteries of boilers representing a total capacity of 1,500 horse-power. Four of the boilers are 500 horse-power Sterling boilers and two are 250 horse-power Altman-Taylor boilers. The coal consumed in them averages 39 tons per day and it takes 15,000 tons of coal to run the plant one year. Three attendants are able to tend the boilers, for the coal feeding down from overhead hoppers is fired to the furnaces by automatic stokers. By the use of these stokers with induced draft systems, practically smokeless combustion is obtained. The combination of coal and ash handling machinery with automatic stokers greatly reduces operating expenses in the plant. From the time coal is sidetracked at the station, until the ashes are dumped into cars, no hand shoveling is necessary.

The dynamo room contains two electrical generating units each directly connected to a Corliss engine; the exciters for

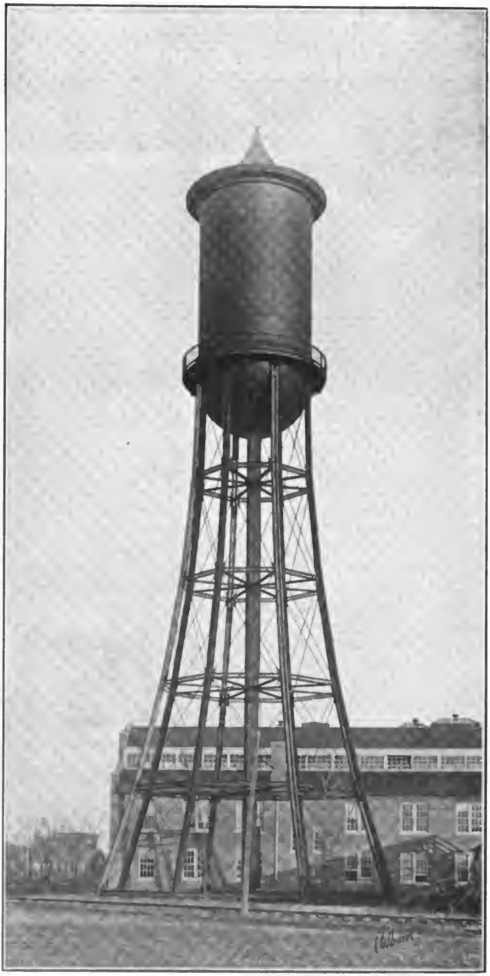
Showing the 250 K. V. A. and 150 K. V. A. Generators

these units; and the switchboard from which all electrical power is distributed. The air compressing machinery is also in this room. Both of the large electrical generators are three phase, 60 cycle alternating current machines operating at 1100 volts. The older unit of the two, has a capacity of 150 K. V. A., and is directly connected to a 250 H. P. Murray Corliss engine. The second unit installed at a cost of $9,500 has a capacity of 250 K. V. A., and is separately excited from a direct current generator driven by a Reliance-Chalmers engine. These two generators representing most improved types of modern electrical machinery, are supplying 5,000 K. W. hours of electrical power daily.

The compressed air pump in the dynamo room maintains a constant pressure of 90 pounds per square inch in an air storage tank located outside of the building. A 30 H. P. electric motor directly connected to the compressor automatically starts the pump going when the pressure falls. From the storage tank air is furnished for the thermostats over the entire campus; for the heating system; and for laboratory blow torches. A special trap designed by Mr. T. Sloss, Superintendent of the Plant, is fitted into the bottom of the storage tank to take water and impurities out of the air delivered to the pipe line.

HEATING AND TUNNEL SYSTEM.

Steam heat is used in all of the college buildings, and the pipes needed in the system are carried to and from the Central Power plant in an underground tunnel. Exhaust steam supplemented by live steam from the boilers provide a heating system with a capacity of 92,000 square feet. The main tunnel is



Elevated Water Tank and Tower—Designed by Civil Engineering Dept.

of reinforced concrete, is 5 feet wide and 6 feet high, and carries in addition to the heating pipes, the compressed air pipes, a high pressure steam line, and all electric wires and telephone cables. The cost of the heating system together with the 8,000 lineal feet of tunnels now in use was $96,000. The tunnel construction beside making pipe lines accessible for repairs greatly improves the appearance of the campus by eliminating all overhead electrical wires.

WATER WORKS SYSTEM.

Two 100-foot wells located near the Central Power Plant supply the water for the system. From these wells, water is delivered into a 140,000 gallon concrete reservoir by a Gregg heavy duty propellor pump. This is an 8-inch, 13-stage pump, and has a capacity of 400 gallons per minute. From the reservoir, which serves as a storage, the water is lifted into the water tower by a duplex pump rated at 1,000 gallons per minute. A triplex plunger pump operated by an electric motor is also held in reserve for emergency. At the present time it is necessary to operate the pumps about 12 hours daily, and approximately 300,000 gallons is delivered during that time.

The water tower is of particular interest to Ames Engineers for it was designed by A. Marston, Dean of Engineering. It is 168 feet high and will hold 163,000 gallons of water. At the time of its erection in 1898 it was the largest water tower in the state of Iowa. Illustrations of the tower have appeared in at least four of the standard text books on water supply, and it is considered as a model example in structural design.

SEWAGE DISPOSAL PLANT.

In connection with the water works system might be mentioned the sewage disposal plant, consisting of a septic tank, sludge bed, and three sand filter beds. This plant, designed by Dean A. Marston in 1898 and built the same year, was the first sewage disposal plant to be built in Iowa, and its construction and operation were studied with much interest by Engineers in Iowa and neighboring states. The plant was first designed to serve the college only, but in 1909 an addition was built to afford treatment for the sewage from the Fourth ward of the city of Ames. Aside from furnishing an example of a common type of sewage disposal plant to students in sanitary engineering, the plant has enabled the college experimentalists to make a careful study of the septic process, the results of which have been published from time to time in the shape of bulletins issued by the Engineering Experiment Station.

Summer Surveying

Many of the prominent technical schools of the United States now require of their civil engineering students, attendance at summer surveying courses. It is generally acknowledged that the student cannot, during the school year, perform surveying field work problems on a large scale, or under the exact conditions he will meet in practice, because of the shortness of the field work periods, and the necessity of keeping such work in the immediate vicinity of the campus. It is with a view to supplying this broader field experience that summer surveying courses are offered, and the following is a brief description of such work, as given at Iowa State College.

Summer surveying courses are held during the first two weeks of June in each year, and each civil engineering student is required to attend at least once.

Hydrographic Surveying—Sounding Lake Okoboji

For the past seven summers, this work has been held in the beautiful Okoboji Lakes region of northwestern Iowa, and the work remaining there, according to present plans, will require as many more summers for completion. An area seven miles east and west by eleven miles north and south is being surveyed and a complete topographic map of this territory will be made, drawn on a scale of 1,000 feet to the inch. This area includes

West and East Okoboji Lakes, Spirit Lake, and many smaller bodies of water, and is known throughout the United States as a summer resort. The region is well suited to the work in hand, since on account of the variety of the topography, the relief, and the large amount of water surface and shore line, it presents a great variety of problems for the surveyor.

A Topography Party at "The Lakes"

The work done is of several different kinds. First, triangulation stations are established on prominent points, the positions being chosen with a view to making strong figures. Two base lines have been measured with long steel tapes, with an accuracy of 1 in 500,000, and a third will be laid out and measured in the near future. The angles of the triangulation system thus laid out are marked with suitable signals and all the angles read, with repeating or direction theodolites. The triangulation is then calculated and adjusted, this work being usually done at Ames during the school year, by the Junior students.

With this triangulation net work as a basis, topography parties, using either transit and stadia or plane table and stadia, take the topography and sketch in the field maps on a scale of 400 feet to the inch, showing all bodies of water, prominent buildings, fences, roads, railroads, and ten foot contour lines. These field sheets are transferred by pantograph, with suitable

checks, to the final map, which is on a scale of 1,000 feet to the inch.

Another part of the work consists in sounding all lakes of any size and recording the depths on the map. This is done from a launch or from row boats.

Thus, not only do the students gain valuable experience, and incidentally a splendid outing, but an area of 77 square miles, in a part of the state widely known as a summer resort, is being thoroughly surveyed and accurately mapped, and the results will eventually be published as a bulletin of the Engineering Experiment Station, and will then be available for use by all the people of the state. Thus far about one-half of the area has been mapped and it is planned to publish in the near future, an advance bulletin describing the work already done and giving a reproduction of the map in its present state.

Miners at Summer Camp

Engineering Inspection Trips

Few people outside of the Engineering Division are familiar with the inspection trips taken each year by the members of the Senior classes in Engineering. It has long been contended by the practicing engineer that students are altogether too unfamiliar with the practical work and practical methods of performing engineering work. Heads of departments and teachers of engineering have been learning that there is a reasonable ground for some of the above criticism. With this criticism in mind and in accordance with the college motto, "Science with Practice," the college shop-work has been supplemented by the annual inspection trips which have been held for the past twelve years.

These inspection trips are taken by the students in all branches of engineering, and are generally made to Chicago, Milwaukee and vicinity. The mechanical and electrical engineers usually go together accompanied by a professor from each department. These men while in Chicago inspect such plants as the South Side Elevated Co.'s power plant, the Commonwealth Edison Co.'s plant, and the works of the Western Electric Co., and a large cement plant. The works of the Illinois Steel Co. at South Chicago, and that of the Indiana Steel Co. at Gary are also visited.

In Milwaukee the men are taken through the works of such concerns as the Allis-Chalmers Co., the Nordberg Manufacturing Co., etc.

The civil engineers visit some of the same places but with a different purpose. At the American Bridge Co.'s plant the men see the work of designing and assembling structural steel, and also the steel in process of manufacture at the South Chicago and Gary plants. All sorts of steel and concrete buildings, railroad terminals, etc., are visited, especial attention being paid to inspection of construction work.

In the case of the miners, the trip to Chicago is taken every two years, and a summer camp in the west is held in the intervening years. On the metallurgical trip, the men visit the steel and cement plants in Chicago and Gary, the Standard Oil refinery at Whiting, Ind., and the zinc plants at LaSalle, Ill. In Milwaukee mining machinery is seen at the Allis-Chalmers and other plants. The summer camp is usually held at Idaho Springs, Colo. One has been held in the Bingham copper district of Utah. The camp lasts about two weeks, during which time the men visit the mines, mills and smelters that are available. A careful study is made of mining, concentrating and smelting methods. Side trips are made to Breckenridge, Leadville, Pueblo, Colorado Springs.

Engineering Societies

ENGINEERING SOCIETY.

The Engineering Society is primarily the "get together" organization of the engineers. All engineers are eligible to membership upon payment of the dues. All the student activities of the Engineering Division are directed through the organization of this body. It's president names all committees on student affairs, and all activities are carried on in the name of the society. The Campfire in the fall, and the Open House meeting in the spring, are the two social functions for which the society is famous.

Meetings of the society are held the second Wednesday evening of each month. At these meetings lectures are given by prominent engineers, or matters of interest to all engineers are discussed by the membership. The various department societies suspend one meeting a month in favor of the general society meeting.

AMERICAN INSTITUTE OF ELECTRICAL ENGINEERS.

A number of years ago the American Institute of Electrical Engineers adopted the progressive policy of establishing branches of the parent society all over the country. Along with this policy came the plan of permitting students of established educational institutions, who are pursuing a course relating closely thereto, to obtain certain of the benefits of this great organization. Accordingly, by the payment of nominal yearly dues, an undergraduate taking a course in electrical engineering may become a student of the A. I. E. E. He is permitted membership in a local branch, and is elegible to some of the offices in the branch with which he is identified. In addition to this, the proceedings of the institute are regularly mailed to him.

The Iowa State College branch is one of the oldest of these branches, being established in 1903. Meetings are held twice a month, these being given over to addresses by prominent engineers and to discussions by the local membership.

AMERICAN INSTITUTE OF MINING ENGINEERS.

In 1910 the American Institute of Mining Engineers recognized the advantage of affiliating student societies of technical schools with the parent body, and made possible the establishment of local branches. Very soon after the inauguration of this policy, the Mining Engineering Seminar reorganized into the I. S. C. Branch of the American Institute, and became one of the first societies affiliated with the national organization.

Meetings of the societies are held once a week, except when suspended for the regular monthly meeting of the Engineering Society. Discussion of live topics in mining and metallurgy is the usual proceedure.

CIVIL ENGINEERING SOCIETY.

The Civil Engineering Society was organized in the fall of 1910, the object being to rejuvenate the old Junior and Senior seminars, which were gradually losing their popularity and value. It was felt that more good could be obtained from addresses by prominent engineers and others than was being derived from the student papers presented before the old seminars, so the latter disbanded and the C. E. Society became a reality.

Among the prominent engineers and others who have addressed the Society, are J. A. L. Waddell, Consulting Engineer of Kansas City; Isham Randolph, Chief Engineer of the Sanitary District, Chicago; N. T. Guernsey, Attorney, formerly of Des Moines, now of New York City; F. E. Turneaure, Dean of Engineering at Wisconsin University; and others.

The social end of the Society's aims has not been neglected. A hearty spirit of enthusiasm prevades the society, and many student celebrations which have happened in the past five years could be traced to its door. A smoker is held once each term, and other little affairs tend to keep the members bound together in a close bond of fellowship.

TAU BETA PI.

Tau Beta Pi is an honorary engineering fraternity which was founded at Lehigh University in 1885. Iowa Alpha Chapter was installed at Iowa State College in December, 1907, being nineteenth on the chapter roll of the fraternity and the first chapter to be installed in the state.

The primary requisite for membership in Tau Beta Pi is scholarship, no one being elegible to membership who does not stand in the upper one-eighth of his class while a Junior, or in the upper one-fourth of his class while a Senior. This applies only to male students in the engineering courses in the institution in which the chapter is located.

But scholarship is not the only criterion by which members are selected. A man must have proven himself to be a student in the broad sense of the term, and must give promise of some time being a credit to his Alma Mater and to his profession. Furthermore, he must be a man among men; he must be looked upon by his fellows as a companion whose acquaintance is to be desired and cultivated.

Iowa Alpha chapter now numbers between thirty and forty members, including faculty and graduate members, and is considered one of the strong chapters of the society.

The Engineering Courses

The Iowa State College offers engineering courses in civil, mechanical, electrical, mining and agricultural engineering and in ceramics. In addition to these courses special provision is made for students who wish to specialize in illuminating engineering and industrial chemistry.

The engineering courses are the same as those given in all first class engineering schools and in such universities as Wisconsin, Illinois, Ohio, etc.

The courses are based upon high entrance requirements and assume very complete preparation in the students electing them. They have been outlined with a view to securing thorough training in the principles of engineering practice and the theory upon which such practice is founded.

For admission to either of these courses the student is required to present fifteen high school credits, each representing a five hour course carried throughout the high school year covering not less than thirty-six weeks and the class periods being at least forty minutes in length. To insure more complete preparation in the candidate the number of credits which may be offered in any one subject is limited. At the same time in subjects regarded as fundamental in importance certain minimum requirements are established. To be more specific, in mathematics three credits are required. In English the requirement is also three credits. In history one credit is required and in foreign languages two. For the remaining six elective credits a variety of subjects may be offered with limitations as to the total credit allowed in any one.

Students may and sometimes do enter the college in other ways, for example, by transfer of entrance credits from other institutions, by examination, etc., but in all such cases the equivalent of the credits above described is insisted upon.

These entrance requirements are high and compare favorably with those of the leading engineering schools, in point of fact, they are distinctly higher than those adopted by many such institutions.

The engineering courses have been developed with reference to the needs and opportunities of the young men of Iowa who are looking toward engineering as a life work. They embody the knowledge and experience of the foremost educators and the practice of the leading technical institutions.

Certain educators profess to believe that all college and university training should be general and cultural in character giving specific training along no particular line. Others would

put engineering college work upon the trade school basis, teaching the superficialities of manipulation and manual training, giving no attention to underlying theory and including nothing of purely cultural nature. Unquestionably the ideal engineering course is one which avoids both of these extremes, one which provides instruction in the theory and practice of engineering and includes a sufficient number of cultural subjects to give broad and liberal training.

The courses in engineering at the Iowa State College in addition to the purely technical subjects include instruction in English, Foreign Languages, History, Literature, Political Economy, Mathematics, Chemistry and Physics as required subjects, and as electives, Public Speaking, Psychology, History, etc. On an average two thirds of the student's time is devoted to technical and one third to cultural subjects. These figures are based upon the assumption that the required subjects above mentioned with one exception are culture subjects and without technical value. Physics is classified with the purely technical subjects. This classification will be rejected by many since the cultural value of physics will be admitted by all, while some of the subjects listed, particularly mathematics and chemistry have large technical value. Furthermore many of the technical courses have distinct cultural value. This is true of such courses as, geology, descriptive engineering, technical lectures and the seminars. Notwithstanding the fact that it may be open to some objections the classification here proposed will serve as a basis upon which to compare the technical courses offered by different institutions.

Anyone sufficiently interested will find by comparing the curricula of the leading engineering schools that the training secured by a student of this institution is broad and liberal and at the same time complete from a professional standpoint as evidenced by the scope and sequence of the technical subjects presented. Such comparison will also show that as regards breadth of training and liberal culture the courses here offered compare favorably with those of the leading technological institutes and engineering schools conducted as departments or divisions of universities.

To meet increasing demand for engineers having a still broader training than that afforded by the four year course the college offers five year courses in Engineering, which secure to the student larger opportunity for both cultural and technical work.

Brief statements of the scope of the courses offered by the individual departments together with other items concerning lines of work open to graduates, etc. are given below.

CIVIL ENGINEERING

The course of study in Civil Engineering has been maintained since the opening of the college in 1869, and is a strong four year

course, whose general features are similar to those of the other engineering courses, as discussed elsewhere. In the senior year students are offered an option between three separate lines of work, namely, in railway engineering, hydraulic engineering, and structual engineering.

The Civil Engineering Course affords suitable training to engineers desiring to pursue general surveying, general civil engineering drafting, drainage engineering, irrigation engineering, water power engineering, river and harbor improvement, highway engineering, railroad engineering, water works engineering, sewerage engineering, pavement construction, city en-

The Civils at work—"Science with Practice"

gineering work in general, and, in fact, all the various branches of the civil engineering profession.

The equipment of the Civil Engineering Department is located partly in Engineering Hall, partly in the Annex Building and partly in the Structural and Hydraulics Laboratory, which are separately described. The Civil Engineering Faculty includes six professors and three instructors.

MECHANICAL ENGINEERING

Instruction in Mechanical Engineering has also been given from the date of opening the college in 1869.

The course in Mechanical Engineering has been arranged to

give its graduates the best possible training for such positions in the profession as consulting engineer, contracting engineer, heating and ventilating engineer, sales engineer, efficiency engineer, works manager, purchasing engineer, machine designer, chief draftsman, foundry superintendent, machine shop superintendent, railway engineer in charge of motive power and rolling stock, superintendent and manager of electric light and power plants, gas works superintendent and engineer, refrigerating engineer, telephone engineer, valuation engineer, patent office expert, mine operator and manager and many others of equal magnitude and responsibility.

The lines of work mentioned above are taken at random from a recent list of graduates in Mechanical Engineering.

The graduates in Mechanical Engineering are to be found holding positions of highest engineering responsibility in every branch of the profession as well as positions of public esteem in every state of the Union and in many of the countries of the world.

The buildings and equipment devoted to carrying out the course of study are described elsewhere. The work of instruction occupies the full time of seven professors, eight instructors and part of the time of one student assistant.

ELECTRICAL ENGINEERING

The course in Electrical Engineering was established in 1891 and has been steadily strengthened from year to year, keeping pace with the rapid development in the field of Electrical Engineering. The training given and the specific courses required are such as to fit the young men with the best possible foundation for professional positions such as designing, superintendence of construction or of operation, management of railway, lighting or telephone properties, or sales engineering. Opportunity is offered in the senior year for a choice between electric railway work, power transmission, or illuminating engineering.

The equipment is housed in the Engineering Annex, described elsewhere. The faculty includes besides the Head of the Department, an Associate Professor and an instructor.

MINING ENGINEERING

The department of Mining Engineering was established by the General Assembly in 1894. The entrance requirements are the same as those of the leading mining schools of the middle west, and the course covers about the same ground as the courses offered at Ohio, Pennsilvania, Illinois, Minnesota and Missouri.

The student in the Senior year may elect special work along the lines of mining geology, mining engineering, metallurgy and ore dressing.

The students who have completed the course are equipped to accept positions in state and federal geological surveys, as mine foremen, assistants in mining engineering, and as assistants in samplers, mills and smelters, mine surveyors, and serve as foremen in the installation of mining machinery and equipment.

The department shares quarters with the other engineering departments in Engineering Hall and Engineering Annex.

CERAMICS ENGINEERING.

The department of Ceramics was established by legislative enactment in 1906. The course is patterned after the courses offered at the University of Ohio and at Rutgers College, New Jersey. The student is thoroughly grounded in chemistry, physics, and geology, and is given sufficient work in mechanical and electrical engineering to fit him to accept positions of responsibility in the clay and cement industries.

INDUSTRIAL CHEMISTRY

The course in Industrial Chemistry was established in 1909. The student is thoroughly grounded in theoretical and applied chemistry, and is given special training in mechanical and electrical engineering. The graduate in industrial chemistry is eligible to positions as chemist and foreman in various manufacturing plants, especially soaps, paint, varnish, oil refining, paper, starch, glucose, sugar, cement, heavy chemicals and coal tar products.

Industrial chemistry shares quarters with ceramics in the Engineering Annex and Ceramics building.

AGRICULTURAL ENGINEERING.

The course in agricultural engineering was established in 1909, and provides training in those branches of engineering related to agriculture.

This course is designed to fit graduates for such work as managing and superintending farms where drainage, irrigation, and the use of agricultural machinery is a large factor, for professional work in drainage and highway engineering and for positions in the farm machinery industry requiring mechanical skill and a knowledge of the science of agriculture.

The department is housed in Agricultural Engineering Hall and Agricultural Engineering Annex. Twelve professors and instructors devote their time to this work.

Iowa State Highway Commission

When the General Assembly constituted the Iowa State College at Ames as a State Highway Commission, none of the Mississippi Valley states had taken a responsibility of this nature. Various highway commissions or departments had been established and were on a successful working basis in a number of the eastern states notable among these being Massachusetts and New Jersey. Shortly after the early eighties, public sentiment began to demand a definite plan for road improvement. The demands for systematic road improvement were brought before each legislature but no definite action was taken until 1904 when the bill presented by Representative Jones was passed after some amendments. This act in brief stipulated that the Iowa State College of Agriculture and Mechanic Arts should serve as a State Highway commission for Iowa, and with duties as follows:

1. To devise and adopt plans and systems of highway construction and maintenance, suited to the needs of the different counties of the state, and conduct demonstrations in such highway construction, at least once each year at some suitable place, for the instruction of county supervisors, township trustees, superintendents, students of the college, and others.
2. To disseminate information and instruction to county supervisors and other highway officers who make request; answer inquiries and advise such supervisors and officer on questions pertaining to highway improvements, construction and maintenance in said county, and so request and agree to furnish necessary tools, help, and motive power for same, the commission shall furnish as soon as practicable thereafter, a trained and competent highway builder for such demonstration free to the county.
3. To formulate reasonable conditions and regulations for public demonstrations; and to promulgate advisory rules and regulations for the repair and maintenance of highways.
4. To keep a record of all the important operations of the highway commission, and report same to the governor at the close of each fiscal year.

To conform with the provisions of this law, the Board of Trustees of the college appointed the Deans of Agriculture and Engineering as Directors of this Commission. Thos. H. MacDonald was appointed Highway Engineer. The general offices of the Commission are quartered in the Engineering Hall of the Iowa State College of Agriculture and Mechanic Arts. The early efforts of the Commission were directed towards an educational campaign to awaken public sentiment to the immediate necessity of the betterment of road conditions. Road meetings, county in-

stitutes, farmers' picnics and gatherings of a similar nature were attended where outlines and plans for road construction and maintenance were discussed. The construction and use of the road drag in connection with road maintenance was explained and advocated. Many stretches of experimental roads were constructed over the state from which much valuable data was obtained regarding the methods of construction and maintenance of roads adaptable to Iowa conditions. It was in this demonstration and experimental work that the close alliance between agriculture and Road Engineering was brought to view. Rural communities were brought into closer touch with each other, consoli-

Campus Driveway Improvements—work of the Highway Commission

dated school districts were made possible and the marketing of farm produce at all times of the year, all resulted from improved highways. Experimental culverts were constructed by the Commission and demonstrations showing methods of placing reinforcing steel, building forms, etc., were carried on in many parts of the state. The counties were ready and willing to adopt plans along the lines suggested and much good resulted from this early demonstration work.

It soon became apparent that before any attempt of permanent road construction could be successfully carried out, it would

be necessary to find a solution to the bridge problem. Practically all of the bridges in the state at this time were built of wood and the cost of replacing and maintaining these was consuming the entire bridge fund of the counties.

Attention was then turned towards permanent bridge construction which was aided by the growing popularity of concrete as a building material. Much of the work of the Commission of the past few years has been directed towards preparing standard plans and specifications for concrete and steel structures with the aim in view of securing permanent bridges at a reasonable cost to the counties. A few of the most prominent highway bridges constructed under plans and specifications prepared by the Commission are as follows:

> *The Kilbourn Bridge*, a steel span on concrete piers and abutments costing $24,000 built over the Des Moines river at Kilbourn, Iowa
>
> *The Cliffland Bridge*, a steel span on steel tubes, costing $23,500.
>
> *The Main Street Bridge* at Mason City, Iowa, an 80' arch span with a 70-foot roadway costing $18,000.
>
> *The Eureka Mill Bridge*, five seventy-foot concrete, arches costing $21,000 built over the Raccoon river near Jefferson, Iowa.

During the past year plans have been prepared for over one hundred and fifty individual structures ranging in size from small culverts to the largest highway bridges. The total cost of the structures built under these plans would amount to several hundred thousand dollars. Surveys of proposed road improvement including plans and profiles have been prepared for many of the counties in the state. Approximately one hundred and twenty-five miles of completed surveys have been made by the Commission since the first of the year.

The work of the Commission is confined at present to the preparation of plans and specifications for bridges and roads, the checking of designs submitted to them by the counties for approval, the preparation of reports on existing and proposed structures, the educational features of highway work including county institute, convention, experimental and demonstration work for highway improvement. The work of the future for the Commission will be dependent upon the phases of the work demanding the greatest attention and the support received from the state.

Engineering Experiment Station

The Engineering Experiment station was established at the Iowa State College by the State Legislature in 1904. Since that time it has carried on the commercial testing and investigational work which previously had been done by the several divisions of the Division of Engineering. Its object and purpose is to serve the industrial, urban, and rural interests of the state in engineering as does the Agricultural Experiment Station in agriculture.

The sum of $3,000 was appropriated each year for the biennial period beginning in 1904. This sum was sufficient to equip a chemical laboratory and employ two assistants who took care of the commercial testing, and also did such research work as they could with the limited equipment and funds at their disposal. However an investigation of Iowa's Portland Cement resources was inaugurated and deposits found which now supply the three Iowa Portland Cement factories. Investigations concerning sewerage and water supplies were begun which have yielded valuable data for use in designing water works and sewerage systems for Iowa conditions.

Subsequent legislatures have increased the appropriation for the work of the Engineering Experiment Station until, at present, $10,000 per year is available. The scope of the work has been extended until it covers the several branches of engineering represented at the college. The aim of the Station is to become one of the leading factors in Iowa's industrial development, as well as a source of reliable information and an authority concerning the problems relating to urban and rural life.

The work of the Engineering Experiment Station is carried on under the supervision of A. Marston, Dean of the Division of Engineering, assisted by a council composed of the head professors of the several engineering departments. The Station Council recommends all lines of investigation that are carried out and approves the methods to be employed.

The general scope of the work of the Experiment Station is becoming quite extensive. An investigation of the coals used in Iowa for steam purposes is now being completed and an investigation of the merits of the several types of oil engines used in Iowa for power purposes is under way. Commercial tests of power, heating, and pumping plants, tests of mechanical and electrical apparatus, and calibration of instruments such as water meters, pressure gauges, electrical meters, etc., are made by the station. Investigations of the mineral resources, the reclamation of industrial wastes, improved methods for the analysis and testing of raw materials and finished products as well as

the commercial testing of ores, clays, water, sewage, bearing metals, asphalt, structural materials, fuel, etc., are also performed by the station.

Because of its physical testing laboratories, the Civil Engineering Department of the college had been called upon for many years, to furnish information and make tests of the materials of construction used thruout the state. This important line of work is now carried on by the Engineering Experiment Station. Investigations relating to the problems of drainage, sewerage, testing of materials, railways, good roads, etc., have been taken up and a number of valuable bulletins have been issued.

Because of its importance in this state, the subject of drainage has been given much attention. The methods for testing drain and sewer pipe have been investigated and inexpensive machines designed for this purpose. The earth pressures to be carried by pipes have been investigated by a series of tests such as have never before been attempted. The best methods for tiling the several kinds of Iowa soils is being investigated in cooperation with the Soils Section of the Agricultural Experiment Station. Examinations and tests of the materials used in street and lighting construction will be made and the results published. The commercial testing of the materials of construction is increasing so rapidly that the present laboratory facilities are becoming inadequate. As many samples were tested during the month of July 1912 as in the two year period of 1909 and 1910. A similar increase in work is true in the other lines of work of the station.

The Engineering Experiment Station is cooperating with the Agricultural Engineering Section of the Agricultural Experiment Station in the development of the "Iowa Cycle" gas engine which gives promise of being a valuable addition to our power producing machinery.

Several important investigations relating to public roads and the design of reinforced concrete arches has been made in cooperation with the State Highway commission.

The results of the various lines of investigations are published in bulletin form for general distribution.

The opening of the laboratories of the Engineering Experiment Station to the officials of the small towns of the state, which cannot afford the services of a testing engineer, has resulted in a more permanent construction of their public improvements. The Engineering Experiment Station is a most valuable asset to the college and state and is bound to be of ever increasing value.

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EDITORIAL

The State Board of Education of Iowa, in dealing with the engineering situation in the State, has outlined plans to develop at Ames "the greatest technical institution in the Mississippi valley along the lines of agriculture, engineering, and veterinary medicine. In addition provision has been made for a complete system of industrial education, which will reach the great multitude of youth of 14 to 18 years of age who are not attending our secondary schools. The fact that the state of Iowa is rapidly increasing in importance as a manufacturing state is an indication that we must provide for the education of our in-

dustrial classes in the same way that we already reach the agricultural classes. To do this it is necessary to have at the head of the system, a college of engineering which shall turn out the highest grade of professional engineers. With such a technical college as a basis, there can then be established a state-wide system of trade schools.

That Ames is graduating the highest grade of engineers is amply proven by the success of our engineering graduates, and by the positions they occupy. It is well recognized that an engineering education should be broad in every sense. To determine whether or not this requisite is being met by the Engineering School at Ames, it is but necessary to point out that Ames engineers are occupying some of the most prominent positions in their professions. Furthermore, Ames has always touched the industrial and commercial life of the state in a most practical way. The statements of some of Iowa's leading manufacturers in regard to the work done by the college, are given elsewhere in this number. They speak for themselves.

The announcement of the Board's plans and the statement that Ames was to be made the center of the industrial educational system resulted in the publication from the State University of many erroneous and misleading statements. To correct these statements, and to boost for engineering at Ames is the purpose of this issue of "The Iowa Engineer". The two-fold development of Iowa as a great agricultural and industrial state depends in a large measure on the manner in which the status of our engineering schools is decided. The welfare of the state as a whole is the deciding factor, and the material herein presented is given only with the idea of assisting all concerned to reach a correct solution.

There is an increasing demand and necessity for instruction in home economics all over the country. In the past, too little attention has been given to the training of girls to take their place in the home life. Now such work in home sanitation, home decoration, cooking, sewing, etc., as is given in the Home Economics courses at Ames is recognized as essential in a girls' education. This training should be provided not only at Ames and Iowa City, but in all colleges and high schools of the state as well. The trend of modern education in all lines is to teach those things which are essentially useful and practical to as large a number as possible. To discontinue the home economics course at Ames will deprive the farmer the privilege of sending his daughter to a school in sympathy with farm problems. The fact that this is the case, and that any girl will be denied the privilege of getting an education in a place best suited for that purpose, is strong argument for continuing the Home Economics courses at Ames.

Why Engineering is and Should Be at Ames

By B. H. Hibbard*

That Senator Justin S. Morrill had a clear vision of the educational needs of the people is evident from the relation of the land grant colleges to problems of life. Nearly all American colleges before 1862 were of the classical type.

The Morrill Act was passed by Congress in 1862 and gave to each state an amount of public land, or land scrip at the rate of 30,000 acres for each member of Congress. Iowa was under this act entitled to 240,000 acres of government land, to be located within the state. This amount was reduced considerably by the selection of some land valued above the minimum price. The legislature of Iowa promptly accepted the grant on the terms prescribed in the Federal Act. It is the meaning of this act that is now of special interest.

Had Iowa, as did many states, added the new endowment, together with the courses of study prescribed or implied in the grant, to the state university, no controversy of the kind now brought to the front would vex the colleges and the state. But at that time there was grave apprehension as to the ability of a college of the new type to hold its own in competition with the time-honored curricula of the universities Iowa, like many other states, put the land grant college a supposedly safe distance from the university.

The wording of the Morrill Act is plain and the discussion which accompanied the passage of the act through Congress is in exact accord with this evident meaning. The greater part of the talking was done by Mr. Morrill himself. He explained that there were abundant opportunities for students to study the professions of law, medicine and theology, but little opportunity for a study of industrial branches of learning. He said more about agriculture than about engineering, but what he did say about the latter was so telling that no fair student of the case could entertain a doubt. Mining engineering was singled out especially in these unmistakable words:

"The mineral wealth of our country, already disclosed, assume almost unbounded proportions; but destitute of experience as we are and largely dependent upon the skill of those but half-

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taught from other lands, our mines are much less remunerative than they would be under the control of Americans, with some fundamental instruction in their vocation."

No less to the point was his utterance concerning the mechanics. And do not for a moment imagine that the mechanics, as he called them, were merely the men working for so many cents an hour in the shops. He says:

"There is no class of our community of whom we may be so justly proud as our mechanics. Their genius is patent to all the world. For labor-saving contrivances, their tact seems universal, and whenever any one of them is detailed to do the breathing of any engine, he speedily furnishes lungs for the engine to do that sort of work for itself. But they snatch their education, such as it is, from the crevices between labor and sleep. They grope in twilight. Our country relies upon them as its right arm to do the handiwork of the nation. Let us then furnish the means for that arm to acquire culture, skill and efficiency.

"The farmer and the mechanic require special schools and appropriate literature quite as much as anyone of the so-called learned professions."

This is a lofty sentiment. The man who puts breath into the inert metal in order that it may do his bidding takes high rank among the professional men of the world. And Mr. Morrill, recognizing the character of the work, implored Congress to provide the means for that arm to acquire culture, skill and efficiency. In this is shown in few strokes the outlines of a full-rounded course in engineering, even engineering capable of measuring in a dignified way up to the standard of other professions.

Again he couples the name of the mechanic with that of the farmer as in need of an appropriate literature comparable to that used by the learned professions. Did anyone ever hear from a source worthy of attention a statement to the effect that the graduates of trade schools needed a literature for aid in reaching their highest development, which was to be likened to that needed by the doctor, lawyer, or minister? No doubt, the blacksmith and the carpenter need literature, but they do not use it daily as a tool in their shops. It would hardly seem that a fair judge would ask for any further testimony as to the intent of the law.

The important consideration is no doubt the law itself rather than the things said about it. In the Morrill Act, we read that each state which accepts the offer shall use the funds obtained as an endowment for the "support and maintenance of at least one college where the leading object shall be, without excluding other scientific and classical studies, to teach such branches of learning as are related to agriculture and the mechanic arts, in

such manner as the legislatures of the states may respectively prescribe, in order to promote the liberal and practical education of the industrial classes in the several pursuits and professions in life."

Here agriculture and the mechanic arts are put exactly on a par. In their support are to be taught, as the legislature shall prescribe, supporting studies, even the classics. And worthy of repetition is the phrase "in order to promote the liberal and practical education" of the industrial classes. Nothing merely elementary, or mercenary or below caste is here specified, and the result is to be a fitting for the "professions of life." Manifestly not the medical or legal professions, but there is a recognition of professions in the industrial lines.

Iowa established an engineering school at Ames apparently with a clear conscience. There was no suggestion that it should train mechanics in the narrow sense. Never have the graduates been prepared mainly for the routine work of the machine shop. We may have failed to develop carpenters or iron molders, but the graduates of the engineering department have designed marvelous steel bridges; they have dredged harbors; have planned terminal railway stations, which are models of beauty and utility; have drained water from wet land; have put water upon dry land; have designed and installed electric railway systems; have even built a sea-going railroad. But from time to time comes the charge that engineering does not belong at Ames. Ingenuity is exercised to show that if we are to have engineering at all, it is to be agricultural engineering. Probably these critics do not understand that agricultural engineering involves a large part of the whole science of mechanical, civil, and electrical engineering, the bounds of which no man dare presume to set. To concede us a department of agricultural engineering is to concede us all the fundamental engineering work in all the engineering courses and a large part of the special technical work in mechanical electrical and civil engineering.

It has also been discovered that engineering is in need of good associations. It requires a portion of culture. Well and good, the Morrill Act provides for the same. Doubtless at Ames, as in many other places, the zeal for efficiency in the immediate work required of the engineer has reduced to a questionably small amount the portion of cultural studies, but they are by no means entirely wanting. And in fairness the universities will have to admit that not all of their professional graduates are brilliant in general scholastic attainments. The ideal is still to be reached. It is not clear, however, that an engineer is more in need of this kind of training than is the professional agriculturist. A belief that the educated scientist in agriculture is not in need of all the vehicles of expression, and the weapons and

accoutrements of mental contests, and even the manners of polite society argues ignorance of the facts. The best modern educators have come to believe and say that all thorough technical educational work is in itself "cultural." Yet at this late day we hear that an engineering school, in order to reach the full fruition of its development, must be located in the midst of culture; the sordid and barren environment of an agricultural college is not conducive to its unfolding. But again from other quarters, comes the lamentation that agriculture cannot prosper in the vicinity of engineering. To both of these classes of *a priori* reasoners we would say: *"Look at Ames!"* No apology is needed for the agricultural college at Ames. She has students from every quarter of the earth. No advertisement is needed for the engineering school, for her children are on every continent helping to subdue the earth and have dominion over it.

Hence no sophistry or quibbling is needed to justify the location of the Iowa State engineering college. It was provided for by federal law, and has since been further provided for by many state laws. It has grown through the years, and is past the experimental stage. It is reaching out to help Iowa in road building, bridge building, land drainage, and manufacturing. If Iowa State College is to be an institution of higher learning, it should be recognized at once that in many respects she must offer courses in the sciences, ranking with university studies of like name. If the atmosphere at Ames is unfavorable to the development of professional engineering, it should at once be clarified and lighted.

I. S. C. has a right to an engineering school. This right is based on contract, on years of possession and years of development.

It is entirely fitting that I. S. C. should go ahead with the work so well begun in the higher lines of engineering. It is also fitting, even highly desirable, that she should connect herself more closely with the industries of the state. Iowa is rapidly becoming important in manufacturing. The need for the application of engineering skill to the trades and industries of Iowa is apparent. That I. S. C. should therefore become a trade school is, however, not evident. Trade schools are for the most part adapted to the needs of young boys 14 to 18 years of age. There are the boys who drop out of school at the close of the eighth grade, or before. They are in the shops and the shops are not in Ames. The thing I. S. C. can do, and is planning to do, for these boys is to assist in the establishment of classes for people at the places where they are employed, and then furnish instruction through a corps of extension teachers. Moreover, there should be trade schools in every county in the state, but especially in those centers where the industries are already established.

One of the greatest examples in the world of the usefulness of the trade school is found in Germany. Nearly every town or city of any size has one or more such schools. They fit the needs of the neighborhood. In the forest region they teach the trades pertaining to wood work; in the mining regions they teach the trades which deal with mining products; in the industrial centers they teach trades in which machinery is much in use. They deal with the men in the ranks. The instruction takes the place in great measure of the old apprenticeship system. Its purpose is efficiency, and it has been a prime factor in bringing Germany up from a low grade industrial nation to one of the first rank.

However, Germany does not rely alone on the so-called practrial education in industries but has a great number of technical schools of collegiate grade, none of which are located at universities. These are all bound together into a complete system reaching from the shop to the class room and laboratory. Exactly this is what I. S. C. is taking steps to accomplish here. It does not mean a lowering of college standards. In fact to lower the standards of the college would make it impossible to carry out the full plan lower down, since the teacher should always be in advance of the pupil. There is one important difference between the German problem of education and the American problem. The German workman is anxious to excel in the trade as a workman. Higher education is mainly for the sons of families of means. In this country the boy who finds himself rising in the trade is more likely to attempt to rise beyond the trade so far as doing work at the bench or forge is concerned. Hence the system of education should be continuous, making the road as easy as possible for the man of ambition and ability. There should be no sharp turn or violent transition. The institution which furnishes the instruction lower down should be vitally connected with, or a part of, the one which deals with the professional side of the work higher up. To leave at I. S. C. the lower part of engineering and to develop at S. U. I. the higher part would be like terminating a ladder somewhere in the middle portion on the side of one building and starting again on another at the same level just abandoned with the hope of providing means of continued ascent.

Relation Between Agricultural and Engineering Education

BY RAYMOND A. PEARSON.*

I am asked the question,—Can Education in Agriculture and Education in Engineering prosper together?

My answer is,—Decidedly, Yes, just as well as education in French and Education in American History can prosper together, or as well as education in any other two subjects can prosper together. A few years ago agricultural education was not "prosperous;" that is to say, there were not many students in our agricultural educational institutions. What was the reason? Prospective college students are keen to find the courses of study that will lead to the best openings for their life work. As a rule, they choose wisely. They ought to do so for they are advised by clear-thinking, well-posted parents, whose highest hopes they represent, and by good friends in touch with the world's activities.

It is only a few years ago that young men were flocking to our colleges of engineering. This was their response to the call fro mthe great engineering activities of the country and age. Colleges of agriculture then attracted few students. The industry of agriculture could not offer such inducements to the great majority as were offered by the engineering and other professions. The men who were engaged in practical agricultural work were not meeting with success, as the world judged success—such as came to men in engineering and other professions. It is true that many young men were attracted from agriculture into engineering. Doubtless, many young men were also attracted away from the law and from medicine and from other courses of study into engineering. But this situation did not present an argument for separating other kinds of education from engineering. So far as agricultural institutions were concerned in those days they had few students whether they were associated with engineering institutions or not.

Conditions have changed. Agriculture now offers many inducements to well educated men, and the prospective college students with their friends have observed this fact with the result that our agricultural institutions are now attracting large numbers. The best proof that agricultural education and engineering education can do well when established in the same in-

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stitution is that they do do well when so established. In many institutions, and probably without a single exception, they are doing well together. This is the case at leading universities and colleges of the country such as the University of Illinois, University of Wisconsin, Purdue University, Cornell University, and especially the Iowa State College of Agriculture and Mechanic Arts. In some of these the numebr of students taking agriculture exceeds those in engineering. It is so, at least, at Ames and Cornell University. Members of faculties often have pointed out that the conditions favoring good educational work in agriculture favor also good work in engineering and vice versa.

There are very strong reasons why engineering and agriculture should be taught at the same institution, and with the development of these great subjects, the reasons are becoming stronger. Modern agriculture is largely an engineering enterprise, and it is becoming constantly more so with the increased use of machinery. There are few factories that have more complicated machinery than is now found on well equipped farms. On the other hand, engineering problems of today, especially in the state of Iowa, are closely related to and largely depend upon agriculture. Land drainage is an illustration. Such work in Iowa represents an expenditure of hundreds of millions of dollars, and every separate job even so small that it involves the expenditure of only one hundred dollars, requires skill in both agriculture and engineering if it is to be well done. Irrigation, good roads, power transmission, conveying machinery, construction of buildings, water supply and sewage disposal are other illustrations of agriculture and engineering supplementing one another.

Agriculture and engineering to a large extent require the same fundamental courses in science. This foundation work is not best given merely as pure science, but as science applied to the great professions which are to be served. Chemistry, physics, geology, botany, bacteriology are some of the sciences cammon to both agriculture and engineering. In some cases engineering follows a subject farther than agriculture goes, and in some cases agriculture follows a subject the farther. But in most mases a large part of this fundamental work in science is identically the same for the two professions.

The two professions also require the same character of so-called general or culture studies, including English, languages, public speaking, history and economics. Who can say that the educated engineer needs more or less of this kind of instruction than the educated farmer. Engineers and well-trained farmers are needed in the public affairs of town, county, state and nation, and their practical usefulness will depend largely upon their training in this latter group of subjects. Both in agricultural and in engineering education as much work in these subjects is

introduced into the courses as is feasible. But dependence is more and more being placed upon the training of the students before entrance.

A sufficient reason for this state to have engineering education and agricultural education at the same state institution is that these lines of work were established by the Morrill Act passed by Congress in 1862, and the terms of which have been accepted by the legislature of Iowa. The terms of the Morrill Act having been accepted, a contract exists between the state and the nation, and it provides for instruction in branches of learning relating to agriculture and the mechanic arts. The two kinds of work are recognized as of equal importance, neither is subsidiary to the other. As the national law uses the words "College" and "Professional," the grade of work intended in each line is clearly indicated. The laws also provide for instruction of subcollegiate grade, and under this provision the State College is extending its benefits to all classes of people.

The wisdom of Senator Morrill and his colleagues, and all others who have later assisted in promoting educational work in agriculture and engineering of equal grade in the same institutions, has been vindicated so many times and in so many states, that it is hard to understand how this combination can now be questioned.

Agricultural Engineering and its Relation to Other Engineering Courses

By J. B. Davidson.

Agricultural engineering is to be likened to mining engineering in that it is the engineering connected and identified with an industry. The pursuit of agriculture, conceded to be the greatest of all industries, requires in every phase a multitude of mechanical operations whose execution involves engineering methods.

Agricultural engineering did not attain early recognition as a distinct branch of engineering, no doubt due in part to the fact that it lies between two great branches of education, agriculture and engineering. In seeking recognition, it was not necessary to create an entirely new science, for agricultural engineering is largely an adaptation of civil, mechanical, and architectural engineering to the requirements of agriculture. It is true, however, that new branches of agricultural engincering have been developed and extended.

Agricultural engineering as now generally recognized, consists of at least seven branches:

- Farm Machinery;
- Farm Power;
- Farm Structures, including Rural Architecture;
- Farm Sanitation;
- Drainage;
- Irrigation;
- Public Roads.

The first four of these are of the more recent development and relate directly to the farm ,while the last three have reached a higher state of development and relate largely to the agricultural community.

A knowledge of all branches is valuable to those who would make the farm the object of their life's work. Almost anyone may be made a speciality in itself.

The function of the Department of Agricultural Engineering at Iowa State College is to give instruction in agricultural engineering subjects and investigate the problems related thereto. The instructional work is divided among the students in the general agricultural courses, who will find some agriculural engineeringtrainingnecessary to theirsuccess, and to students who are preparing for agricultural engineering, a specialty or a profession.

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At the present time the greater part of the effort of the Department is required for the former class of students. Practically all agricultural students are required to take courses in agricultural engineering during both semesters of the freshman and sophomore years.

Four years ago, a four year course in agricultural engineering was outlined which is believed to be the first of its kind in the country. The success of this course has been pronounced from the beginning. The success of the graduates from the course, who so far have been college graduates or students with advanced standing before entering the course, has been unusual. The increase in the number of students has exceeded all records. Starting with three freshmen the first year the course was announced, the number has increased to fifty-three. There are eight candidates for degrees in agricultural engineering this year, several being graduates from other institutions.

The agricultural engineering course is outlined so as to give a thorough foundation of mathematics and other sciences upon which agricultural engineering depends. The usual cultural studies are not neglected. The general courses in agriculture are included that the student may understand the scientific methods of agriculture and be in sympathy with them. The balance of the course is made up of the study of the seven branches of agricultural engineering previously outlined. How thoroughly these branches may be considered, can only be determined

The New Gymnasium—A part of what will be the best athletic equipment in the west

by a careful study of the outline of the course. It is desired to state that the strictly agricultural engineering work is considered to be thoroughly covered.

A strong agricultural engineering course is equally dependent upon the very best instruction in agriculture and engineering given by specialists in their respective branches. In other words agricultural engineering will reach the highest state of development at Iowa State College when supported by strong departments of engineering and agriculture.

The extent of this dependence may be illustrated by the following summary of the instruction outlined in the agricultural engineering course for next year.

	Credit Hours	
Chemistry	8 2-3	
Agricultural Engineering	25 1-3	
Civil Engineering	10	
Economic Science	3	
English	8	
History	2	
Mathematics	20	
Mechanical Engineering	22	
Physics	10	
Total engineering course subjects		109
Elective, largely engineering		10
Animal Husbandry	6	
Dairying	2 2-3	
Agronomy	16	
Horticulture	5 1-3	
Total agriculural subjects		30
		149

The conditions for the development of agricultural engineering at Iowa State College are the very best. Both the Agricultural and Engineering Divisions of the College seem determined to make and maintain this new course, the first to be organized, the best in the world.

Plans for the Future Development of the Division of Engineering

The Iowa State Board of Education in its biennial report for 1910-12 to the Governor and Legislature has stated a great and inspiring program for the development of all lines of the states educational work in the three great state schools, and for the development of the schools themselves. Its plans for the development of the educational work at Ames are stated in the following words:

"An institution at Ames which shall be the greatest technical institution in the Mississippi Valley along the lines of agriculture, engineering and veterinary medicine, with college standards as high as the highest; and, supplementary to this, work along sub-collegiate lines which shall bring the beneficent influences of this institution within reach of all those who have only so much as a little time to devote to fitting themselves to do well some of the ordinary work which the world always has to do in abundance."

Concerning the engineering work proposed at Ames the Board makes the following argument:

"The contention that engineering cannot be adequately developed at the College of Agriculture and Mechanic Arts, is not tenable. The work which this institution has done up to the present time speaks for itself. It numbers among its alumni men who have done some of the most notable tasks accomplished in engineering in recent years. Incident to the courses in agriculture and in veterinary medicine, there are at Ames, and there always must be, strong courses in the sciences, in English, and in the modern languages. * * * If there be anything in the argument referred to, then the best plan, under the conditions that obtain in Iowa, is to do what has been done in medicine and law, that is to raise the standards of admission to, say, two years of college work, outline it, and let prospective students in engineering take their preparatory work at the University or wherever they choose. We do not look upon this argument as practical. Some of the best engineering schools in America are not connected with universities, nor do they maintain extensive cultural courses. The Massachusetts Institute of Technology and the Troy Polytechnic Institute * * * are separate and apart from colleges of liberal arts.

"It is to be stated, moreover, in favor of the engineering department at Ames, that it has touched the commercial and industrial life of this state, * * *."

And again:

"We have, and shall continue to have, at the College of Agriculture and Mechanic Arts, a large engineering school with a strong faculty. The splendid professional spirit which has always existed at that institution will be intensified and the people of Iowa will have cause to be prouder than ever of their engineering school. Besides, every competent student who desires may have the benefit of training in this institution."

The plans of the State Board of Education for the development of the Division of Engineering at the Iowa State College go much further, however, than the mere provision of the strongest professional engineering work. The plans amount to establishing a complete system of industrial education for the entire state, and are stated by the Board as follows:

"A state-wide system of engineering industrial education for Iowa would provide effectively and efficiently for all the principal demands of the State upon industrial schools. Eventually, it must provide for educating fifty per cent more youth than are at present attending all the high schools of Iowa.

"First: It must provide for the training of the great mass of the youth who engage in the several trades, in such a way as to make them efficient workmen, equipped with such knowledge of modern science as is required in this present day of wonderful industrial scientific development, and further equipped with such general practical education as will enable them to make the most out of their lives. Only in this way can we secure state or national efficiency, and that happiness and comfort of the individual which are inalienably his right.

"A trade school course and trade school extension courses will constitute the most effective beginning in Iowa in this sort of training, and must always remain a most important part of it. It is especially adapted to Iowa conditions, since we have such a large number of comparatively small cities which cannot afford to hire experts or provide expensive equipment for the work. The extension classes and correspondence study work should eventually enable every youth or adult engaged in the mechanical industries of Iowa to continue his educational training which earning his daily living.

"Second: A state-wide system of industrial education should provide more extensive technical training for considerable bodies of highly expert workmen and foremen, to meet the demands of special industries in different localities. This will call for the gradual development of quite a number of trade schools in the State, each serving effectively a particular locality. These trade schools will not need to be established in any particular locality until the demand there has become so real as to be accompanied by a willingness to pay for a very considerable part of the expense. However, these trade schools should receive state aid, and be under general state supervision in addition to direct control by local boards, so that they may fit in properly with a state-wide system of industrial education.

"The experience of the world has demonstrated clearly that no single trade school can serve a state, and that any individual trade school can properly serve only one community. We must have a whole system of trade schools to meet Iowa's need.

"Third: There are many scientific problems of modern industrial development which require for their solution scientific laboratories and equipment, and technical skill of the highest order, such as cannot properly be provided by the individual manufacturer. Hence, the State should provide a state engineering experiment station, devoted to the service of the State in solving our technical problems. A beginning has already been made in the present Engineering Experiment Station at the Iowa State College, but its resources are at present too limited to enable its work to be very effective.

"Fourth: The State will need a considerable number of expert engineers, of managers, of business proomters, and of owners and operators; for all of whom the best educational training is a complete

professional course in engineering. The professional course at present given at the Iowa State College should be supplemented and modified by the introduction of instruction along lines of business engineering, so as especially to train the graduates of the engineering college for taking part in the general industrial and engineering development of the State.

"Finally, it may be added that in a proper system of state-wide education for Iowa, all the four lines of work enumerated much be centered under one management, and at one institution, to secure the best results. There is no doubt whatever that the continuation of a policy of division, with no relation between the scattered efforts at industrial education in the State, would be a very real and great disaster for Iowa. 'United we sand, divided we fall' is especially true of industrial education for Iowa at the present time."

The carrying out of these great plans is vital to the welfare of Iowa. As the Board of Education further states: "All students of the present economic situation in Iowa agree that the state is about to experience a very large and important development of our manufacturing industries. Such a development is absolutely essential to the best interests of the state. During the ten years from 1900 to 1910 the State of Iowa lost ten per cent of its strictly rural population, which is now no larger than it was thirty years ago. No state can develop properly in one line alone, and the agricultural interests of Iowa will be benefited at least equally with others by a development of our mechanical industries commensurate with our standing in agriculture. In fact, many of the problems of agriculture can be solved properly only in a state which has a symmetrical, all around development, in agriculture, in manufacturing, in commerce and in mining.

That there is to be a great manufacturing development in Iowa is not a matter of theory alone. Already much has been accomplished along this line. Mr. Wrightman, the secretary of the Iowa State Manufacturers' association, states that between 1900 and 1911 the annual value of manufactured products in Iowa increased from $133,000,000 to $335,000,000, a percentage of increase many times that in the raw agricultural products of the State. Soon the annual values of our manufactured products will largely exceed even the value of the year's raw products of Iowa's rich farms. Moreover, it was only the industrial development of the State, occurring in our larger cities, which has prevented a material, almost fatal loss in our population between 1900 and 1910.

All friends of a Greater Iowa should actively support the great plans of the State Board of Education for the adequate and systematic devedopment of industrial education in Iowa.

Our Alumni

The real criterion by which to judge any school is the quality of graduates it turns out, and the part that they play in solving the world's problems. Judged by this standard, no one can question the success of the Engineering Division of the Iowa State College in graduating high grade professional Engineers. Within the past year the Engineering Division has issued an alumni directory, in which there appears a write-up of every engineer graduated prior to 1912. This directory is one continual record of engineers who have gone out from Ames to serve the practical needs of the country in engineering lines. Represented in forty-three different states, and in eleven foreign countries truly Ames engineers are known the world over. It is not the function of this article to enter into detailed discussion of our Engineering Alumni. This will be done in the December issue of the "Alumnus".* We do not believe, however, that this issue of "The Iowa Engineer" would be complete without at least a brief mention of a few of the Ames engineers, who have been connected with some of the largest engineering projects of the present day.

W. C. Armstrong, B. C. E. '81 is now Bridge Engineer for the C. & N. W. railroad, with headquarters in Chicago. He designed and superintended the construction of the high railroad bridge at Boone, Iowa. The new North Western passenger terminus just completed in Chicago was also designed by Mr. Armstrong. In January of this year he was elected president of the Western Society of Engineers.

Geo. W. Catt, B. C. E. '82, was at the time of his death in 1905, president of the Atlantic, Gulf and Pacific Dredging company, which company carried out some of the biggest bridge and dredging contracts of this and other countries. Notable among these works was the improvement of Manila harbor, a project which involved the expenditure of $4,000,000. At the time of his death he was consulting engineer for some of the largest engineering firms in the United States.

At work on the Panama Canal, is E. E. Lee, B. M. E., '02. He is assistant mechanical and electrical engineer and superintendent of erection on the Gatun hydro-electric station. His services have been engaged by the Isthmian Canal commission since 1907, and he has had charge of designing on nearly all phases of the great Gaun Lock.

Joseph Carroll Meredith, B. C. E., '78, at the time of his death in 1909, was chief engineer of the extension across the Florida Keys of the Florida East Coast railway. Practically the whole success of this great engineering feat it due to the superior

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ability of Mr. Meredith. At the time of his death, the Times-Union of Miami, Florida, said; "The great concrete viaduct to Knight's Key is a memorial of his skill, and will stand for ages as a testimony of his superior engineering skill.„ Mr. Meredith refused to leave this work to go north for his health, and his life was the forfeit.

A. M. Blodgett, B. S. in Eng., '76, is president of the A. M. Blodgett Construction company, Kansas City, Mo. Most of Mr. Blodgett's work has been as contractor on various kinds of construction. His largest work is the Galveston Causeway, which joins Galveston Island and the mainland. This contract alone amounted to about a million and a half dollars.

W. Lee Campbell, B. E. E. , '94 is general superintendent of the Automatic Electric company, Chicago, Illinois. Nearly all of Mr. Campbell's work has been in the field of automatic telephony. Largely due to his efforts this branch of telephony has forced itself into recognition, so that now automatic telephones are being installed in many of the largest cities.

S. H. Hedges, B. C. E., '86, is president and civil engineer of the Puget Sound Bridge and Dredging company, Seattle, Washington. Among his other noteworthy works, is the construction of several dams for power development in the Pacific Northwest. He has been nominated by the nominating committee of the American Society of Civil Engineers for its next vice president.

T. L. Smith, B. S. in Engineering, '76, is proprietor of the T. L. Smith comapny, Milwaukee, Wisconsin. Mr. Smith is the designer and inventor of the Smith Concrete Mixer, a machine which has found a wide field of application in the concrete industry.

Elwood Meade, C. E., '83 is civil engineer and irrigation engineer with the State Rivers and Water Supply commission, Melbourne, Australia. Mr. Meade was chosen to take this important place with the Australian government because of his recognized worth as an irrigation engineer. He has had a wide experience in water supply and irrigation fields and has a worldwide reputation.

L. W. Noyes, '72, is proprietor of the Aermotor company, Chicago. He has invented scores of machines and various devices, and for several years manufactured agricultural implements of his own design, such as hay forks and carriers, pulleys, etc. It is believed today that the name "Aermotor" on windmills, gasoline engines for the farm use, etc., stands conspicuously in more widely distributed places throughout the civilized owrld than any other name.

Engineering Education at State Technical Colleges and at Institutes of Technology

BY A. MARSTON.*

There are two kinds of engineering schools in the United States: First, those at state technical colleges (and at institutes of technology); second, those at universities. There are strong and there are weak schools in both classes. There is absolutely no difference in the general grade of work done in the strong schools in each of the two classes, either now or prospective in the future. Each of the two classes of engineering schools has some advantages as compared with the other.

Abroad, the polytechnic institute, which corresponds to the American institute of technology (and state technical college), seems to be the favorite type of engineering school. On the continent of Europe, especially, none of the great universities have engineering schools. In Germany, the most successful of all nations of the world in industrial education, engineering is taught not at the universities but at great polytechnic institutes, which crown the entire industrial educational system.

In the United States the first engineering schools were institutes of technology. From 1802 to 1840 the only graduate American engineers came from West Point, which is still a great engineering school, many of whose graduates have gone into civil engineering work. In 1840 the first class of civil engineers to graduate in America received diplomas from the Rensselaer Polytechnic Institute at Troy, N. Y. Troy is still recognized everywhere as one of the leading American schools of engineering; Stevens Institute is another great engineering school, and both it and Troy are much more narrowly technical than any of the state colleges, for Stevens has taken up only Mechanical Engineering, and Troy until recently held mainly to Civil Engineering.

In the further development of engineering education in the United States many strong schools have been established at universities as well as separate from them. Some of the best in the country are located at our great state and privately endowed universities. The best training for engineers requires that students should be surrounded by an "engineering atmosphere," and that

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instruction in the general subjects should be specially arranged to meet their needs, so that in these particulars universities in which the number of engineering students is small in proportion to the total attendance labor at a great disadvantage, but where there are several hundreds of engineering students, organized into a large, separate college of engineering, many of these disadvantages disappear, or are offset by the advantage of association with other lines of work.

On the other hand, the claim which is sometimes made that universities can give higher or broader training to engineers than first class technical colleges or institutes of technology is entirely unfounded. The Massachusetts Institute of Technology is recognized to give as high a grade of engineering work as Cornell University. The Iowa State College at Ames has the same entrance requirements as Wisconsin, Illinois and Ohio, and teaches almost identically the same engineering courses. There is even more general cultural work in the engineering courses at Ames than in those at the State University of Iowa, where modern language, history and political economy are omitted.

It is true that in engineering, as in medicine and law, there is a tendency to require in the future, a total of six years college work instead of four of graduates, of which two or more shall be general studies. But it is also true, again just as in the case of medicine and law, that these two years of general college work will be required for *entrance* to the engineering school, not taught in it, and that the technical college and the institute of technology can just as readily advance their entrance requirements as university engineering schools when the future makes this development advisable. Moreover, this plan articulates the engineering school better with the whole system of general colleges in the state than any attempt to lay out a six years' course at one school, and six years at one educational institution makes a student too narrow and unfits him for the best work in the actual world.

That the above is the true future line of development of engineering education has been indicated by Mr. Ernest E. McCullough in the December, 1912, volume of the Transactions of the American Society of Civil Engineers, who, after stating that "the writer believes the engineering schools of the future in the United States will probably call for a minimum of six years' work," adds that a certain considerable part of this six years' work "will be given in technical high schools and other preparatory schools, which will mean an added two years of preparation." The University of Missouri has just put this idea into practice by requiring two years of general work above the high schools for entrance to its engineering courses.

The passage of the national Morrill land grant law in 1862 gave a great impetus to the development of engineering schools

both at universities and in separate state colleges. According to Engineering News, the establishment of the Massachusetts Institute of Technology, in 1868, was largely due to the prospect of its receiving, as it still does, one-third of the proceeds of that law in Massachusetts, a fact which, no less than the unopposed establishment of the engineering courses at a large number of state universities from the same support, would seem to demonstrate conclusively that the law called for real engineering work.

In the later development of engineering education in the United States the State Colleges of Agriculture and Mechanic Arts and the privately endowed institutes of technology have held a most important part, and many of them appear in any list of the strong engineering schools of the country. Engineering work in such separate engineering colleges has the great advantage of a greater singleness of purpose than is possible at any university where other lines of work must be paramount, as is so well stated by President Humphreys in the same issue of the Iowa Engineer in which this paper appears.

But the greatest advantage of the institutes of technology and of the land grant colleges is that they are especially adapted to touch closely and vitally the industrial and commercial life of the state. The institutes are generally located in large cities, close to great factories and to large numbers of workmen. The land grant colleges are really bound by the terms of their endowments, as they are now coming to realize, to take an active part in the industrial education of the workmen of the state, and in the actual development of its industries and commerce, as well as to maintain first class engineering courses.

Engineering as a profession is like agriculture, and is widely different from medicine, or law, or theology, in that it is linked in an inseparable way with great industries. There is no sharp class line, as some would have us believe, between the millions of workmen who need some industrial training in continuation classes, the hundreds of thousands of specially expert workmen and foremen, who need training in a whole system of co-operative trade schools in each state, and the tens of thousands of expert engineers, superintendents, managers, business promoters, contractors, and owners who need to have taken regular professional engineering courses.

The engineers, according to the great, historic definition, are those who "direct the great sources of power in nature, for the use and convenience of man." Properly to perform this great function they must have mingled with the privates and the non-commissioned officers of the great industrial army, and have acquired a true and sympathetic understanding of their needs, limitations, and possibilities. The engineer in his ideals must think, not like the doctor or lawyer, simply of rendering efficient personal expert service for a proper personal reward, but of

rendering even higher service, to the state and nation as a whole, by serving as a faithful and efficient officer in great state and national industries.

This is the new ideal of engineering education, now growing even more clear and prominent, and we offer it as a far higher and nobler ideal than that of those who talk merely or mainly of academic training for the engineer. And in this new ideal, of training for engineering public service by closest association with actual workmen and actual industries, the land grant colleges of the United States are, most of all engineering schools, obligated and qualified to take a vital part.

A Campus Driveway

Education for all the People

By James Atkinson.*

An unorganized demand that comes spontaneously from the people is always significant whether this demand calls for changed political, industrial, social or educational conditions. Wherever the state must make the response as is the case in the framing of educational policies there must be a correct interpretation of the wishes of the people, otherwise we cannot hope for an improved social life which is after all, the goal of all industry. While society as a whole will eventually "right" herself yet the more quickly will this be done under an educational system so elastic in its nature as to reach the man at the bench as well as the lawyer, the worker in metals as well as the preacher and the tiller of the soil as well as the man who cures our bodily ailments.

In agriculture we have taken one step. The campus of the agricultural college already extends to the boundaries of the state. Thousands upon thousands of farmers annually receive vocational instruction because of this extension. The fact that the demand for this sort of education has always exceeded the supply only indicates that the state as yet does not appreciate the importance of supplying this demand, otherwise the work would have been provided for more liberally.

Considering the distribution of the state's population it would be a one-sided educational system that would neglect the workers of our towns and cities, and to these in the future it is expected that the engineering department of the Iowa Agricultural College will assume the same leadership that has already been taken by the agricultural department in its relationship to the agricultural people. I can see boundless possibilities for what might be called an engineering extension department at the state college. This department could establish "continuation classes" in the factories and shops of the state, a beginning being made in the most important industrial centers. It could eventually be extended so as to include all towns and cities. These classes could be supplemented by correspondence study courses and in this way the great need of all the people could be met.

The development of the engineering experiment station would mean much to manufacturers of the state by the working out of technical problems which require laboratory facilities. This line

*Mr. James Atkinson is widely known throughout Iowa and the country as editor of the "Iowa Homestead", one of the best known agricultural journals in the county.

of work if it should receive the proper financial support from the state would result in greatly stimulating manufacturing interests.

Already the shops of Iowa produce three-fourths as much wealth as the fields and the increase in the state's manufacturing industries will be agriculture's greatest boone. Our good sense in educational matters will be shown in proportion to the recognition we give to the four great industries, namely, agriculture, manufactories, commerce and mining. The neglect of any one through short-sightedness, oversight or niggerliness means in the end that all will suffer.

As said before we have made a beginning and have demonstrated the practicability of adapting college instruction to the needs of farmers. Why neglect the allied industries? It requires $50,000 or $100,000 to launch this work but such a sum would eventually mean for the state the same leadership in the industries as it now holds in agriculture. In matters of this kind we are lagging behind European countries. In Prussia there are over 3,000 industrial, trade, commercial and agricultural schools with an attendance of 200,000 students. In the city of Berlin there are over 40,000 students in supplementary trade, industrial and commercial schools. In these schools provision is made for all classes including butchers, bakers, shoemakers, chimney sweeps, barbers, wood turners, glazers, gardners, wagonmakers, blacksmiths, tailors, painters, and indeed all workers. In view of their extensive educational system it is not surprising that German investigators who attended the St. Louis World's Fair should report to their government that while the United States had large natural resources, yet little was to be feared from American competition on account of the great superiority of the educational system and the commercial methods now in practice in the Fatherland as compared with those of America.

There is abundant need in this state for the co-ordinate development of agriculture and engineering. The proper underdraining of the wet lands of Iowa would require an expenidture of nearly a half billion dollars. Drainage is just as much a branch of engineering as it is a branch of agriculture and an educational institution can perform a most important service if it can lead to a scientific tiling system. Our 100,000 miles of Iowa roads must be improved. We have thoroughly tested out the old slipshod method but more and more our people are looking to the skilled engineer for leadership in this important matter.

A number of practical farm bulletins have emanated from the engineering department, these including one on the sewage disposal plants for private houses and another on electric power on the farm. This is only a beginning. At the present time

farmers are seeking information pertaining to the installation of improved lighting systems for farm homes. The introduction of the gasoline and kerosene engine and the automobile means the presentation of real engineering problems—problems that in their working out require the talent of the expert. The farmer is interested in fuels for power purposes, and he is constantly seeking those of highest power and efficiency cost considered, and in this he needs the aid of the scientist. There are scores of such problems. It is an economic necessity that the state respond to the demand for this kind of practical information. We already have the educational machinery in our great engineering departments at Ames. Let their usefulness be extended by taking the college to the people—alike the tradesman, the mechanic and the farmer.

Roadway in Winter

Opinions of Prominent Manufacturers, Agriculturists and Educators

OPINIONS OF PROMINENT MANUFACTURERS

G. A. Wrightman is Secretary of the Iowa State Manufacturers' Association, which has a membership approaching one thousand Iowa manufacturers. He writes as follows:

"It is my firm conviction, and has been for years, that no other phase of progress is so important to us as the training of our boys right here in Iowa, to be mechanics and skilled industrial workers.

"No matter where you go in the United States, and to a lesser extent in many foreign countries, you will find Iowa young men the foundation of industrial enterprises, small and great. They go away to school for training and are eagerly seized by the hungry industrial world outside before the superior opportunities at home for occupation and enterprise have had a chance to impress them.

"Every circumstance favors Iowa as a great manufacturing state; we are stretching forward into our appointed destiny with long strides each decade. The cry is for men, trained men. The men *are* the industry. A great industrial state in Iowa without a head training institution at Ames of supreme efficiency is unthinkable. The industries of the state demand an engineering institute there second to none in the world, one that shall not follow but lead the industrial progress of the state, bound fast and firm to every section and city, and open by extension and correspondence to every ambitious worker in the state who feels the urge towards more efficiency, greater value. The time is past due when the manufacturers of Iowa must have schools, under the supervision of the engineering department, to train workers for them in actual trades. The trade schools of Europe have been supplying us long enough; besides, Europe now uses her own best workers.

"There is a far greater field for the engineering department of Ames in the manufacturing industries than there is for the agricultural department in the farm industries. The two industries are highly complementary. The development of our manufacturing state gives to the farms the thing they most need—a keen market close by. Training for both does well together. The successful farmer, also, is becoming more and more a mechanic.

"The only thing that can impede the progress of Iowa factories now is the want of trained men."

Curtis Brothers & Co. are good representatives of Iowa manufacturers. Their particular line is sash doors, blinds, mouldings, etc. They are located at Clinton, Iowa, and write as follows:

"The manufacturers of Iowa are on the lookout continually for men trained to fill executive and staff positions, and there seems to be a very limited supply and no method of training more. The interest in factory efficiency or "Scientific Shop Management" is causing all managers to study their organizations and the result is the demand for trained men.

"Our engineering schools can do the state and their own students no greater service than to arrange courses with a view to satisfying this demand, and any plans toward this end will receive the hearty endorsement of all Iowa manufacturers, and their active co-operation should such courses call for practice or "field work" in the different industries."

Mr. George E. Winter was one of the charter members of the Commercial Savings Bank at Mason City, and for a number of years was its cashier. Later he became director and secretary of the American Brick and Tile Company of Mason City. At the present time Mr. Winter is president and managing director of the Acme Roofing Tile Company of Des Moines, Iowa.

"I only wish it were possible for me to endorse the engineering department of geology and mining in sufficiently strong terms to express my sentiments regarding the same.

"It has been my privilege and also that of my associates in the industry of clay products, to have the knowledge and experience of your department in the examination of clays, both chemical and physical, as well as your knowledge of the deposits of clay shale in many locations within this state. In one or two instances we have depended wholly upon this knowledge given out by your department in the location of clay industries which have proven highly successful. Of course, other conditions were taken into consideration in the enterprise.

"We have found the department very valuable to us in the matter of keeping out of some clay industries which have proven failures and failure was predicted by your department, should an industry in those lines be established. I have in mind one or two instances where enthusiastic men went contrary to the analysis of clay and the advice of your department and established plants which have since proven complete failures.

"The department of geology and mining at the Iowa State College has been of inestimable value to the brick and tile industry throughout the State of Iowa and the state association of brick and tile manufacturers has brought these points out strongly at the annual meetings.

"So many manufacturers depend largely upon the help received from your department.

"It has surely been the means of developing, to some extent,

the clay industries in this state, but you must realize that the clay products manufactured in this state are in their infancy as compared to the possibilities of what can be manufactured from the splendid deposits of shale and clay in Iowa."

Mr. D. F. Morey, Ottumwa, Iowa, was formerly secretary and manager of the Ottumwa Brick and Construction Company, and is at present managing director of the Morey Clay Products Company. He was also proprietor of one of the leading coal companies of Ottumwa.

"We beg to advise that we consider the engineering department of our Iowa State College, as being of great financial benefit to us.

"In times past, we have called upon you for analysis of our clays, and feel that our work has always been done with as much accuracy as promptness—both of which are generally of interest to the man who is waiting for the results of such investigations.

"Taken as a whole, we do not believe that the manufacturers of the state appreciate the benefits to be derived from constant communication with your department—for instance, ourselves, we have been buying softening preparations for our feed water for years, and it just recently occurred to the writer that there was no use in paying somebody a big profit on such a material, when we could probably get a formula from you that would do our work. We have not heard from you yet, in connection with this request, but are confident that when we do, we shall be placed in a position to save a large percent of our expenditures on this one item.

"With her practically undeveloped mineral resources, we cannot but feel that Iowa has a great future as a producer of glass, clay and coal products, and we believe that if the proper co-operation is manifested between your college and the manufacturing industries of the state, there will soon be a bigger and better market for the product of your factory—namely engineers and chemists."

Mr. L. E. Armstrong, Fort Dodge, Iowa, organized the Plymouth Gypsum Company, and later the Plymouth Clay Products Company. Mr. Armstrong is president and manager of both of these companies at the present time.

"I will say that we have found the engineering division of your college a good help to both our gypsum and clay industries, and our going into the manufacturing business was largely due to the tests and information we received on our raw product through your department. It is one of the departments of your college that is a great help and of great interest to the manufacturing industries of the State of Iowa."

Mr. C. B. Platt, manager of Platt Pressed and Fire Brick Company, Van Meter, Iowa, has taken a leading part in the promotion of the brick and tile industry in Iowa. Mr. Platt has been secretary of the Iowa Brick & Tile Association for a number of years.

"We wish to express our appreciation of the good work which has been done by your engineering division, and which we consider has been of great general benefit to the clay industry.

"We are convinced that the future has much in store in the way of benefits which will spring from a continued development of the school of ceramics, both for the state as a whole and the clay industry in particular. We also consider that the work done in the testing of materials has been of great importance and value and we trust that this work may be continued to the extent deemed advisable.

"Iowa has a need for a greater development of her manufacturing industry. The clay industry is important as a consideration in this respect. It is not a perfected industry. During the future rapid development of the state it will be called upon to supply a greater variety and larger quantities of clay products. Questions will arise, important to both the manufacturer and the consumer, which we feel can be more readily and satisfactorily solved with the assistance of your engineering division than would be possible through manufacturing practice alone."

Mr. R. G. Coutts, Grinnell, Iowa, has for many years served his community and the State as general contractor and builder. He was at one time mayor of his city. He has also interested himself in the manufacture of clay wares and cement products At the present time he is executive officer of the Grinnell Brick and Tile Company.

"It does not require a very close observer to discover that the proposed change in the makeup of our educational institutions by the State Board has created quite a ripple of excitement. The agitation shows that the people are interested, and the question naturally arises, are our people really aware of the great benefit that Iowa has received from the various departments of the State College. It is my purpose at this time to speak of the work of the engineering department, and as this is a large field and contains many features which I am incompetent to discuss, I shall confine my remarks to one industry with which I am somewhat familiar, and one in which the engineering department of the College has taken a great interest. I refer to the cement industry.

"In 1904 the cement industry made its appearance in Iowa in earnest. Everybody got to using cement,—very many with absolutely no experience in the business, and I believe that more good cement was worse than wasted that year than in any year before or since. But just at the opportune time the management of the engineering department of the State College came to our relief.

"Early in the spring of 1905 a mass meeting of the cement

users of Iowa was called to meet at the college at Ames. To this call there was a hearty response. Men came from all parts of the State,—some to tell of their success, others to discover if they could, the cause of their failures. There were men who had been using cement for years on the "cut and try" plan, that discovered for the first time that they had yet to learn the rudiments of cement practice. The illustrated lectures given by representatives of the engineering department of the college showed the primitive way cement had been treated by the uninformed, the result of which was total failure. Also as treated according to scientific principles, proper proportion of materials, grading of sand and gravel, proper amount of moisture, proper temperature, care of finished work, etc., these lessons and illustrations were a complete revelation to a large proportion of the men assembled, and from that day the instruction given began to bear fruit. An organization was effected at that time that still exists, annual meetings of which have been held ever since. At all of these meetings we have had the presence and wise counsels of some of the members of the engineering department of I. S. C., and the influence of that organization is felt all over the state. It was this organization in conjunction with the Iowa Brick and Tile Association that was largely responsible for the founding of the school of ceramics, which is furnishing, through the engineering department of the college, information that could not be obtained from any other source.

"And yet this is not all for very largely through the efforts of the faculty of the engineering department, three of the largest and most modern Portland cement factories have been located in Iowa. These mills are now turning out 11,000 barrels of cement daily, thus making a market for our raw materials and furnishing us with our cement supply at our own door. So while we regret the loss with which I. S. C. is threatened in some of her departments, we are glad to know that our engineering department is not to be curtailed, but on the other hand, said department is to be largely reinforced. We say, 'Long live the engineering department of Iowa State College'."

Mr. George P. Dieckmann is chief chemist of the Northwestern States Portland Cement Company, Mason City, Iowa. Northwestern States was the first company to build a Portland cement plant in Iowa.

"During the year 1907, the Northwestern States Portland Cement Company was organized, as the first company to manufacture Portland cement in the State of Iowa. It was naturally a great undertaking, as previous to this no opportunity had arisen to induce the establishment of such an institution. Through the co-operation and assistance of the Engineering and Mining Department of the State College of Ames, we located the right kind of deposits necessary for the manufacture of high grade Portland cement, at Mason City, Iowa.

"The Northwestern States Portland Cement Company manufactures a very high grade Portland cement, but at the time of its first introduction in the market, the consumer and user of cement, who heretofore used Portland cement, were skeptical against the new home product. The Engineering Department of the State College at Ames through their testing of our product and their co-operation and favorable reports, about the new Iowa product, by personal visits of the representatives of the Engineering Division to the plant, became convinced of this high grade product turned out at Mason City and did not hesitate to express their approval whenever the opportunity arose, which in many instances assisted materially in marketing the first Iowa cement, and the Northwestern States Portland Cement Company is indeed indebted to the Engineering Departmen for many favors and hearty co-operation."

Agricultural engineering is a new branch of the engineering profession. It has received its greatest present development at Ames through the harmonious co-operation of the Divisions of Engineering and Agriculture. Mr. L. W. Ellis is employed with a great manufactory of agricultural implements at LaPorte, Ind., and writes as follows:

"Agriculture has become largely a mechanical occupation. The three fundamental factors in modern agriculture are power, seed and soil. Power on the farm is fast becoming mechanical, and the farm today takes more gas engine horsepower than all other combined. Plowing the soil takes three billion horsepower hours a year and agriculturists are everywhere agreed that deeper plowing would give us greater and more profitable yields.

"The selection of seed commercially speaking, is a mechanical problem. The sowing, tillage, harvesting, threshing and marketing involve mechanical operations. In fact in every phase of farm work after the agronomists, the botanists, the bacteriologists, the animal husbandry have completed their plans, it remains for the agricultural engineer to put them into execution. The agricultural engineer is therefore, one of the big factors in agriculture, although on the average farm the same man must be not only the engineer, but combine the qualifications of several of the beforementioned scientists.

Agricultural engineering is therefore closely bound up with the working out of broad agricultural development. It is the height of folly to suggest taking agricultural engineering away from other agricultural departments at Ames. It is equally absurd to think of separating agricultural engineering from civil, mechanical, electrical and the other branches of technical education. There never will be subjects as closely allied as are all the industrial arts that can be strictly divided since the relationships are so firmly interwoven.

"However, agricultural engineering may be made as distinct a profession as any of the others. But the agricultural engineer

must be a broad man with a knowledge of civil, mechanical, hydraulic, electrical, and every other source of engineering, because the farm presents such an infinite variety of problems that the agricultural engineer's education must be broad.

"In making his education broad there is the inevitable tendency to make it shallow, and onthing but the nearby existence of specialized departments of high order will keep the agricultural engineering department up to the high standard which should be set. The instructor who has to teach a great variety of subjects needs close at hand, the sympathy and information of specialized engineers who can go farther in their subjects than he can in all. The agricultural engineering student needs the laboratories of the engineering department on the west campus to open his eyes still further into methods and equipment, for the time will inevitably come when he will be attracted more and more to restricted lines involving more specialized knowledge.

"The agricultural engineer must breath the spirit of an engineering institution if he is to work out the standards for a new profession of as great moment as his is destined to be. There cannot be in the logical order of things a separation of agricultural engineering from the other branches. It must not be at Ames. Farm machinery manufacturers are looking to the colleges for men to help design and refine the machines that have been largely thrown together by the work of untrained inventors. These men must have an insight into agricultural engineering before they can work out a science of farm machinery design.

"The mechanical engineer might design a binder that would work and wear forever, but which would require so much power that no sane farmer would ever thing to hitch a team to it. Engineering to be applied to agriculture must have agriculture mixed in with it. Dean Marston on the one hand and Dean Curtiss on the other, represent two wings of industry that must unite to a certain extent to train the agricultural engineer, for the agricultural engineer's day is here."

OPINIONS OF PROMINENT AGRICULTURALISTS.

It is unnecessary to introduce the Honorable James Wilson, Secretary of Agriculture for the last sixteen years, to anyone in Iowa. He is known throughout the world as perhaps its foremost agriculturist. He has served longer in a cabinet position in Washington than any man before him. His word on agriculture is gospel throughout the country. He writes:

"I am well satisfied that the interests of engineering and agriculture are so closely related in Iowa as to require close association of the educational work in these two lines.

"Second, I have no doubt whatever but that a wise interpretation of the Morrill law would lead one to reach the conclusion

that it did require instruction in engineering such as has been given at practically all of the land grant colleges."

Director A. C. True has charge of the office of Experiment Stations in the U. S. Department of Agriculture, Washington, D. C. No man has had greater opportunities than Dr. True for studying the work of land grant colleges throughout the length and breadth of the country. He writes:

"The very great importance of the subjects included in agricultural engineering makes it very desirable that the State colleges give much attention to working up strong courses in these lines. The large and increasing role of farm machinery in modern agriculture and the great desirability of improved farm buildings, water and sewage systems, drainage, irrigation, and roads, makes it necessary that instruction in these subjects should not only have a sound engineering basis, but should be organized with definite relation to agriculture and country life. This can best be done in those colleges having courses in both engineering and agriculture.

"Without doubt the land grant act of 1862 contemplated the establishment of institutions of collegiate grade which would be broadly organized along vocational and scientific lines. It is in my judgment absurd to hold that professional engineering courses may not properly be maintained in the land grant institutions."

Prof. P. G. Holden is known all over Iowa, and, in fact, all over the United States, as one of the foremost agricultural experts and educators. He was a candidate for Governor of Iowa in the June primaries, 1912, and received a very large vote. He writes as follows:

"I have followed with very great interest the plans for establishing engineering extension work on a very large scale, centered at the engineering division of the Iowa State College. In connection with the maintenance of professional engineering courses of the highest grade at the same place, and with the gradual development of state-aided local trade schools around the state, coupled closely, as at present, with agricultural education, this will constitute a comprehensive, state-wide system of industrial education for Iowa, and be a most essential and important factor in the development of a greater industrial state. All friends of a GREATER IOWA should actively support these plans.

"I am glad that this great work is to be developed at the State College, and in closest association and co-operation with agriculture, for in Iowa all engineering industries and problems are so closely related to agriculture as to require the closest association of educational work in engineering and agriculture. Examples in civil engineering are drainage, farm sanitation, good roads; in mechanical and electrical engineering we have farm machinery, farm power and lighting, mechanical vehicles,

and especially the manufacture of hundreds of millions of dollars worth, each year, of raw products from the farms, and a myriad of articles for the farm. I am absolutely certain that Iowa is about to become a great manufacturing as well as agricultural state, and am confident that this, besides furnishing Iowa farmers a great home market, will make intensive farming really practicable, and will do much to help in the solution of some of the most important agricultural problems.

"In all this the closest association of agricultural and engineering education is of vital importance, including both their extension to the great masses of farmers' boys and young workmen in the trades, and the maintenance, in close connection with such extension, of college professional courses of the highest grade, to train the leaders, investigators and experts. The authors of the National Morrill Law were wise in making it require, as it undoubtedly does, instruction in both agriculture and engineering at the land grant colleges, including professional, college, engineering and agricultural courses, as well as extension and trade school work. I have served personally in the faculties of three of the greatest agricultural colleges in the country, in Michigan, Illinois, and Iowa, at all of which engineering and agriculture are most closely associated, and at all of them I have observed that such association is most helpful. Each line of work stimulates and strengthens the other.

"You have my best wishes in your plans to develop engineering and agriculture at Ames."

Dean H. L. Russell of Wisconsin University is in charge of the Wisconsin College of Agriculture and Experiment Station. He is widely known throughout the country as a most prominent agricultural educator. He writes as follows:

"Relative to the relation of agriculture and engineering, I would say that experience has indicated the wisdom of close association of these applied sciences. Of course, there are certain phases of professional engineering that are not necessarily closely related to agricultural activities, but in connection with the good roads movement, drainage investigations, and at several other points of contact, the work of the engineer and the farmer is brought so closely together that it would be detrimental to the natural order of things to disassociate these activities."

Dean C. F. Curtiss, who has had charge of the Agricultural Division at the Iowa State College ever since 1897, is too well known to the people of Iowa to need any introduction. His reputation as a great agricultural educator is national and international. He writes as follows:

"The engineering work at the Iowa State College has attained a highly creditable standing. Ample evidence of this is furnished by the rank of engineering graduates from this institution in practical engineering work and in professional work in all parts of the United States.

"The engineering work at this institution in addition to being of high grade, has been especially helpful to the agricultural interests of the state, and to the agricultural instruction in this institution. The agricultural courses have been strengthened by the engineering instruction offered here and there is urgent need of further development and co-operation of that kind. Provision should be made for instruction in architecture and application of the best instruction in this subject should be made to the problem of economy, efficiency and sanitation of farm buildings. This is a most important field of service, and it bears a vital relation to agricultural progress and the improvement of farm life. Instead of the agricultural courses in this institution suffering by association with engineering work, they have profited, both in point of attendance and efficiency of instruction, by that association."

Director W. J. Kennedy, of the Agricultural Extension Department of the Iowa State College, is well known throughout the State of Iowa, and, indeed, throughout the United States. He is competent to speak with authority upon questions of agricultural education.

"I have noted with considerable interest the controversy in regard to the influence of engineering on agricultural work. It has been my good fortune to have either attended as a student, or to have been on the faculty of three institutions, namely, the Ontario Agricultural College, Guelph, Canada; the University of Illinois; and the Iowa State College. At the first institution there is just agriculture. At the other two, there are strong engineering courses as well as the agricultural courses. In my observation, both as a student and as a member of the faculty, I must say that I believe that a strong engineering school does not in any way lower the work of the agricultural departments of said school. On the contrary, I believe that they each strengthen the other. They are both interested in the industrial development of the state. When we have more manufacturing lines in Iowa, we will have more people to consume the products produced upon the farm. The two lines of work are inseparable. I sincerely hope that the present policy of the Iowa State College, which is to give high standard courses in agriculture and engineering, will be continued.

"We need well trained men along agricultural lines. These men require just as strong training previous to coming to college as does the man who wishes to be a professional engineer. It is especially desirable in this stage of development of the great State of Iowa that we have the very highest standard of agricultural work and also the very highest standard of engineering work, and in my estimation they will both grow and prosper under one administration. I believe that each will be better for being associated with the other, rather than to have them separated."

OPINIONS OF PROMINENT ENGINEERING EDUCATORS.

Dean Herman Schneider, of the College of Engineering of the University of Cincinnati, Cincinnati, Ohio, has became a national benefactor through his introduction into American engineering and industrial education of the co-operative plan whereby the student in engineering or in a trade spends part of his time in the school and part of the time in the shop during his industrial education. Dean Schneider writes:

"It is not necessary to prove that the new plans for Iowa State College are good plans. They are obviously good. The difficult thing would be to prove that they are not good. Education and all that it implies should not be held sequestered after the mediaeval fashion. The idea of public service is beginning to permeate every branch of educational work, and this newer and truer ideal makes it imperative that education go out to where all the people are living and working and performing their civic functions. Your new plans mean that your great educational engine will not stay on the side track at Ames, but will get out on the main line and give service throughout the length and breadth of the state."

"Alex. C. Humphreys is president of the Stevens Institute of Technology at Hoboken, N. J., and is an engineer and engineering educator of international reputation. Upon request of the editors of the "Iowa Engineer" he has prepared the following brief article:

"I certainly do believe that the 'ideals of engineering education in the future can be entrusted to an institute of technology such as Stevens is'. I suppose that your question refers to the comparative efficiencies of the separate college of engineering and the University college? If so, I say each has its advantages over the other, and I hold that there is no one best way of doing anything when we consider the peculiarities and idiosyncracies of the human beings involved as teachers and learners. I believe that the separate college or institute of technology has a distinct advantage in being free to shape its work beyond the control of men ignorant as to the problems involved, or not in sympathy with the work in general. One of the greatest obstacles which the separate colleges have to contend with is the apparent tendency of men of great wealth to give to the universities rather than to the small colleges. We in the United States are inclined to be unduly impressed by size and numbers rather than by quality.

"I am firmly of the opinion that the work of the engineering colleges is sadly handicapped by the superficial preparation of the applicants for admission. Having said this with regard to our work, I may go further and say that I believe this applies also to the colleges as a whole. This leads me to the statement which I wish to make with emphasis—We, at Stevens, do not look for or desire a specialized preparation; we do ask for a

thorough preparation in the general study subjects, and we should like to find that the applicants for admission had been really drilled in the—shall I say, despised?—three Rs. Personally I am quite opposed to the idea that because a boy is preparing for a college course in engineering, his preparation should include certain practical studies *to the exclusion* of more general studies. These practical studies should be of great value to all, but the engineer-student will get them later, so he can better afford than can others to miss them in the preparatory stage of his training. Here is where I shall be misunderstood. Of course it is well that the engineer-student should get all possible practical training during the practical period, *but not at the expense of the 'cultural studies'*. I greatly dislike to use the term 'cultural' in this connection, for I hold that all studies are cultural if efficiently presented, taught and learned. There must be some choosing and picking, for unquestionably our public school curricula are overcrowded, with general superficiality and neglect of the three Rs as the result. How many teachers really appreciate that *facility* and *accuracy* in arithmetical computations will later greatly assist in the actual work in higher mathematics?"

Some very misleading statements have been made in Iowa about Purdue University, and partial statistics have been quoted in away to give a very wrong impression as to the developments of agricultural education in that institution. President W. E. Stone of Purdue mentions this fact in a recent letter, and further states:

"Purdue University, like other land grant institutions, has been constantly in a state of development, as it is now. In its earlier days its officers very wisely saw that the institution could be developed more rapidly on the engineering side, and that agricultural development would come slowly. They took advantage of this condition by strengthening the engineering work, but not at the cost of the agricultural work, which has always received more than its due share of funds and attention based on the number of students in attendance.

"By this policy the institution was given a name and standing in the state on account of which it enjoys public confidence. The agricultural development is now coming more rapidly and stronger than it could otherwise have done.

"At the present time the school of agriculture is the largest of any in the institution. Over 500 students were enrolled last year, and a larger number this year. The records simply show that agriculture has been more slow in starting, not because of the organization of the institution, but because the people of the state have been slow to "catch on." This they have now done, and I venture to say there are few states in the union where ther is a strongr and healthier sentiment toward the agricultural college than in Indiana, or where the work of the College, station and extension department is better co-ordi-

nated or more largely attended, and it is a fact that Purdue University is frequently referred to as a model organization for this kind of work."

Director Albert W. Smith is head of the Sibley College of Mechanical and Electrical Engineering at Cornell University, which probably enrolls more mechanical engineering students than any other college of engineering in the country. Director Smith writes:

"From 1874 to 1878 I was a student in engineering at Cornell, and from 1887 to 1891 I was assistant professor in engineering at Cornell and since 1904 I have been in charge of the work of mechanical engineering at Cornell. During all the time it has seemed to me that the relation between the engineering students and the students of agriculture has been most pleasant and that it has been most profitable to both. I have always considered that one of the chief advantages in studying engineering at Cornell is the opportunity to meet men in other lines of work with the resultant broadening tendency and among those to help in this tendency, I would put in a very high place the student in agriculture.

"I believe that with the industrial development of the United States in the future, the work of the engineer and the agriculturist will tend more and more toward over-lapping and interdependence, and that therefore, it is of the very greatest importance that schools of agriculture and engineering should be so placed that the students may associate with each other."


IOWA STATE COLLEGE

Engineering Education in the State Schools of Iowa.

ESTABLISHMENT OF ENGINEERING INSTRUCTION.

It was not until many years after Iowa became a state that engineering instruction was afforded her young men within her own borders, and it then fell to the lot of the Iowa State College to offer such work. With the opening of the college in March, 1869, courses in civil and mechanical engineering were established, and eight engineering students finished these courses in November, 1872. These courses antedated by at least four and one half years any other engineering courses in Iowa, and were real engineering courses, with a faculty of strong professors and mechanical equipment as well as surveying instruments. Two of the professors were G. W. Jones and Wm. A. Anthony, afterwards noted as strong men in the faculty of Cornell University, Ithaca, N. Y.

The next engineering course in Iowa was established in 1873* at the State University of Iowa. There was not an engineering faculty, but a single professor, and no engineering equipment of note other than a small investment in surveying instruments. The classical courses and the Liberal Arts work in general were paramount, and even in the engineering course necessarily overshadowed the true engineering work. Cornell College, at Mt. Vernon, Iowa, also established a course in Civil Engineering in the same year.

At Ames, the engineering faculty grew in numbers and strength, and a real engineering plant was developed, with separate buildings, with shop equipment, with steam and general engineering laboratory equipment, etc., as well as surveying and draughting equipment. The engineering courses were made up mainly of real engineering work, such as was being given at the best engineering schools of the country, and were not padded out with general college work. Most important of all, perhaps, the engineers at Ames studied in a sympathetic engineering atmosphere, and were not submerged in a large body of classical students.

One of the best evidences of efficiency of any institution is

* It was the custom at the old time classical colleges to have the Professor of Mathematics demonstrate a few problems in surveying to his classes in Trigonometry, and to provide a surveying instrument or two for this purpose. The State University of Iowa followed this custom prior to 1873.

the work of its graduates. While, as has been said, it might be strange indeed if a few of the early graduates did not "make good," yet it becomes significant when large numbers of them attain great prominence in their profession, and rank with the foremost engineers and builders of the country. Men like A. M. Blodgett, Willis Whited, J. B. Marsh, G. W. Catt, M. J. Riggs, W. C. Armstrong, M. E. Wells, T. L. Smith, W. C. Swift, Elwood Mead, A. C. Andrews, J. C. Meredith, J. E. Porter, S. H. Hedges, J. C. B. Lockwood, C. M. Canady, F. L. Pitman, C. L. Schermerhorn, Alfred Williams, and numerous others have demonstrated by their records the high grade of early engineering work at Ames.

The history of engineering education in Iowa need not be picked from catalogs and other printed reports alone, when the real facts can be obtained from men who know them, and who have followed closely the trend of education in this state. The whole period is within the vivid remembrance of Dean E. W. Stanton, who has been connected with the Iowa State College during the entire time. Both he and Judge John L. Stevens, of Boone, graduated with the first class of engineers who ever received diplomas in Iowa. These two men and six others graduated in 1872 after pursuing four years study in regular courses in civil or mechanical engineering at the Iowa State College.

Those who rely entirely upon the printed records would find that not until 1878 is it possible to tell from the degrees granted by the Iowa State College what students completed the engineering courses. This is simply because the Bachelor of Science degree was the only one granted for all courses of study at the College. It is only from these men who *know* that the real facts can be obtained.

GROWTH OF ENGINEERING ATTENDANCE.

Until 1892 the growth of engineering attendance was comparatively small. In that year the total engineering graduates of the state were:

State University of Iowa	59
Cornell College, Mt. Vernon	61
Iowa State College	123
Total	243

In the year 1892-3 the enrollment of engineering students in the state schools was as follows:

State University of Iowa	50
Iowa State College	179
Total	229

An inspection of table I and diagram 1, showing the engineering attendance at various schools, will prove interesting. From 1890 until 1893 or 1894 there was a normal increase in such attendance. The business depression immediately following checked this growth, and in some cases caused a slight decrease. As business conditions improved, a growth in engineering attendance was observed, and the ten years immediately following

TABLE I.

ENGINEERING ATTENDANCE AT VARIOUS SCHOOLS.

YEAR	Cornell University	Purdue University	University of Illinois	Ohio State University**	University of Wis.	University of Missouri	University of Minn.	University of Neb.***	Iowa State College	State Univ. of Iowa****
1890-91	561	186	138	------	137	68	74	------	81	42
1891-92	643	271	150	------	162	109	108	------	128	39
1892-93	691	305	190	------	179	132	152	------	149	50
1893-94	702	362	206	------	201	147	145	------	168	50
1894-95	633	340	224	------	225	139	159	------	147	48
1895-96	626	359	226	------	207	134	191	------	144	38
1896-97	640	347	210	------	218	161	181	------	135	41
1897-98	640	355	211	------	227	170	159	------	137	32
1898-99	696	377	231	300	242	188	161	------	103	31
1899-00	774	465	244	282	327	245	209	------	210	45
1900-01	784	637	327	472	411	304	265	------	304	51
1901-02	1,006	782	412	572	513	367	345	------	399	------
1902-03	1,143	949	524	648	585	435	394	------	441	69
1903-04	1,290	1,067	685	712	744	465	396	------	503	78
1904-05	1,445	1,140	768	701	804	580	399	------	531	74
1905-06	1,621	1,234	845	766	709	626	412	------	570	102
1906-07	1,547	1,332	970	770	790	648	458	------	592	230
1907-08	1,638	1,402	1,023	834	921	736	473	------	704	249
1908-09	1,731	1,297	1,060	901	866	748	467	------	681	243
1909-10	1,745	1,207	1,057	857	781	659	392	425	602	218
1910-11	1,631	1,130	991	806	807	592	420	412	623	180
1911-12	1,559	1,105	970	744	728	*398	377	384	587	165
1912	1,419	1,096	818	726	655	*353	276	376	585	168

*Two years of collegiate work required for entrance. Fall 1911.
**Statistics not definitely gathered before 1898.
*** In 1900 State Legislature abolished Industrial College and erected therefrom Colleges of Engineering, Agriculture and Medicine. Prior to this time all students in these departments grouped in one college, and now practically impossible to get accurate figures on any one department.
****Chair of Civil Engineering, Liberal Arts College, until 1905, when College of Applied Science was created.

1898 proved to be unparalleled, both in general prosperity and business activity, and in the growth of the engineering schools of the country. This period of growth and expansion had its reaction in 1907 and 1908, and has left its mark on the enrollment records of the engineering schools of the country. The decrease has been general, and not confined to Iowa schools, as some have inferred.

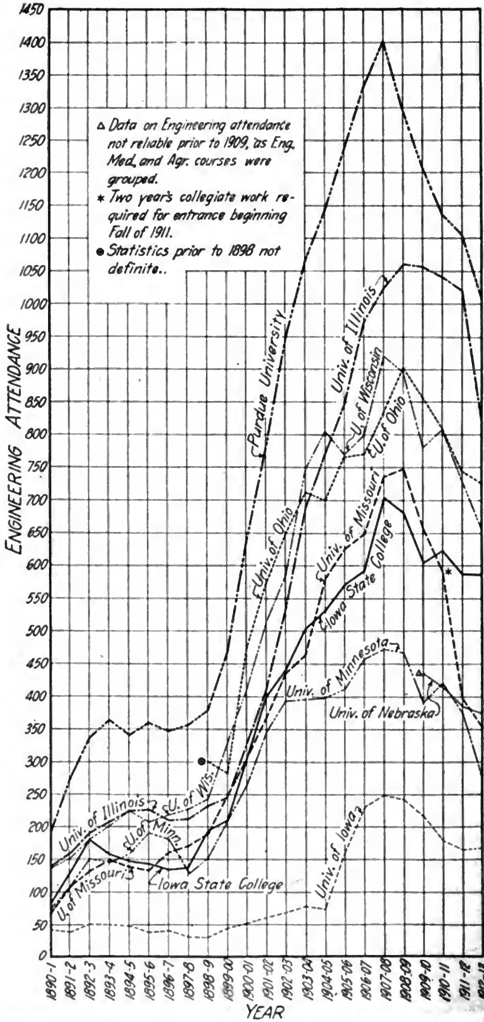

Diagram I. Engineering attendance at various schools since 1890.

ENGINEERING ATTENDANCE AT VARIOUS INSTITUTIONS.

Engineering attendance at the State University of Iowa was practically constant until 1905, when the College of Applied Science was created. It immediately got its stride with the other schools, and experienced the same rapid increase in attendance until the reaction of 1907.

The schools listed in table I have experienced decreases as follows:

Cornell University, from 1745 in 1909-10 to 1419 in 1912 ....18.6 %
Purdue University, from 1402 in 1907-8 to 1006 in 1912 ....28.3 %
University of Illinois, from 1060 in 1908-9 to 818 in 1912 ....22.8 %
Ohio State University, from 901 in 1908-9 to 726 in 1912 ....19.4 %
University of Wisconsin, from 921 in 1907-8 to 655 in 1912 ....28.9 %
University of Missouri, from 748 in 1908-9 to 592 in 1910-11 ....20.9 %
University of Minnesota, from 473 in 1907-8 to 276 in 1912 ....41.7 %
University of Nebraska, from 435 in 1909-10 to 376 in 1912 ....13.6 %
Iowa State College, from 704 in 1907-8 to 585 in 1912 ....16.9 %
State University of Iowa, from about 242 in 1907-8 to 149 in 1911 ....38.4 %*

*The College of Applied Science included 16 students in Chemistry last year, who seem to take no engineering work whatever. The exact number in 1907-8 is not known, but there seem to have been only 3 graduates since 1907, and 233% of this number has been deducted to find the approximate number of engineers in that year.

This checking in growth has not been confined to engineering alone. The total enrollment at the University of Illinois has decreased 20 per cent; that at Purdue University about 5.5 per cent; that at the University of Minnesota 21 per cent; that at the University of Nebraska from 1910-11 to 1911-12, 20.9 per cent; and that at the State University of Iowa 20.6 per cent.

Table II shows the practically steady growth which has taken place at the Iowa State College. The business depression of 1907 caused a temporary decrease, but this has been overcome, and the attendance is now much larger than ever before, having increased nearly 20 per cent since 1909-10.

From Diagram I it will be noticed that the curves for the

TABLE II.

ATTENDANCE AT IOWA STATE COLLEGE.

Compiled by Herman Knapp, Registrar.

YEAR	Long Courses**							Short Courses			
	Post Grad.	Agri.	H. E.	Vet.	Eng.***	Sci.	Total	1-Yr. Dy. 2-Yr. Ag.	Sum.	Win.	Grand Total
1912-13	------	*709	344	68	*555	67	1,743	203	127	614	2,687
1911-12	------	*647	206	85	*587	89	1,567	188	96	614	2,455
1910-11	------	*532	151	100	*623	84	1,476	148	------	595	2,219
1909-10	------	*589	140	115	*602	113	1,543	------	------	627	2,170
1908-09	------	540	125	126	681	142	1,614	29	------	796	2,439
1907-08	------	474	164	108	704	------	1,450	17	------	642	2,109
1906-07	------	440	143	82	592	106	1,363	21	------	765	2,149
1905-06	23	241	116	56	570	96	1,202	8	------	776	1,986
1904-05	------	340	132	60	531	99	1,186	------	------	552	1,740
1903-04	22	334	182	52	503	120	1,213	23	------	558	1,794
1902-03	6	288	118	48	441	142	1,043	88	------	578	1,709
1901-02	------	245	141	59	399	139	983	75	------	300	1,358
1900-01	20	253	85	47	304	144	853	65	------	229	1,147
1899-00	24	206	84	43	210	94	663	151	------	------	814
1898-99	15	209	93	37	193	166	698	120	------	------	833
1897-98	17	118	53	9	157	148	464	44	------	22	547

*Including engineers with special reference to agriculture. These are included as engineers, because they are engineers. They belong to the Iowa State College Engineering Society, and help edit the Iowa Engineer. The members of the Agricultural Engineering faculty are engineers, and members of the Engineering faculty. In the Agricultural Engineering Course, there are 29 credit hours of agricultural work, 13 hours of electives, very generally engineering work, and 107 credit hours of work such as is given in any engineering course. The students are drawn from the other engineering courses, and upon graduation take engineering positions.

**Exclusive of Academic Students.

***Exclusive of Music Students.

State University of Iowa, and for the Iowa State College, show that in Iowa the tendency to decrease in engineering attendance has apparently come to a halt, and that engineering attendance will begin to grow from now on. The very active campaign for students carried on by both schools during the past summer, however, no doubt had some considerable effect upon the attendance. The true facts as to recent and present enrollment in the two schools are shown in Table III.

STANDARDS FOR ENTRANCE.

In the matter of entrance requirements Ames followed in the early days the past and present example of the Rensselaer Polytechnic Institute, at Troy, N. Y., and of West Point, the two earliest and still two of the greatest engineering schools in the country, in omitting Greek and Latin and all the general medley of high school subjects of the old days. Like Rensselaer and West Point, however, Ames did test out all the students enter-

ing engineering courses in the subjects really essential to the successful study of the subjects then taught in the best engineering schools. This was accomplished by applying actual tests instead of accepting old-time high school credits.

At the University, on the other hand, paper entrance requirements were higher, but fortunately actual enforcement thereof was extremely merciful. There is no doubt but that the University and the general run of western colleges of those days acted exactly right in accepting practically every young man of any promise who applied, whether he could meet the paper entrance requirements or not.

In 1897 to about 1900 the paper entrance requirements for the engineering courses at Ames were raised to include the completion of a full four years high school course, a change which came naturally with the improved high schools. At the same time Ames retained, and has continued to the present time, its

TABLE III.

ATTENDANCE OF ENGINEERING STUDENTS.

Year	Ames			State University of Iowa		
	Total Engineers	Freshmen Engineers	Total Engineers	Chemistry	Total Applied Sci.	Freshmen Applied Sci.
1907-8	704		*242	*7	249	
1911-12	587	225	149	16	165	58
Decrease	117		93		84	
Equals	16.6%		38.4%		33.7%	
1912-13	586	274			168	75
Increase		49				17
Equals		21.8%				29.3%

*The numbers of students in chemistry and engineering do not appear separately in the catalogue for 1907-8, and the division of the total in Applied Science between the two is based on the fact that 3 degrees of B. S. in Chem. appear in the Alumni list to have been granted in 1907-11. The chemistry students do not seem to be taking any classes whatever taught by engineering professors or instructors.

The figures for engineering attendance at S. U. I. in 1912-13 were obtained from Professor Ensign, University Registrar.

The figures of engineering attendance at Ames include, as they should, the students in the four years engineering course in Agriculturel Engineering, who are doing true engineering work.

old-time custom of testing out by actual examination or "ten days' review," every entering engineering student in Mathematics and English. A considerable number of students from accredited high schools have always been "demoted" to sub-collegiate work in these subjects for which no college credit whatever is given. The State Universiay of Iowa does not do this. Since about 1900 the *paper requirements* at the two schools have been the same, but *as actually enforced* the Ames requirements have been the stricter.

Ames has been enabled to maintain these stricter requirements by maintaining the old academic course, to which students could be "demoted," and similar classes since its abolishment. The old academic course did not furnish an easy route of entrance, but served to enable the maintenance of stricter entrance requirements.

When the State Board of Education took charge and formed the "Committee of Fifteen" to unify the work of the three state schools, it was found that to make the entrance requirements uniform for Ames and S. U. I. it was necessary to lower the minimum requirements at Ames slightly, and raise those at S. U. I. slightly.

Thus any claim that the larger engineering attendance at Ames is due to lower entrance requirements is entirely incorrect. The requirements at Ames have actually been higher for a goodly number of years, and it may be added that 77 per cent of the present engineering enrollment at Ames has been gained since the old days, before its paper entrance requirements had been raised.

ENGINEERING EQUIPMENT.

During these years the State has provided liberally in buildings and equipment for the training of engineers. At the State University money has been spent with a lavish hand since 1905 for the upbuilding of the College of Applied Science. The inventory recently published by the Student Central Committee of the State University of Iowa is as follows:

Engineering Building	$126,915.12
Steam Laboratory	10,000.00
Engineering Shops	20,000.00
Electrical Engineering	27,000.00

EQUIPMENT.

Mechanical Engineering and Shops...	$ 19,715.00
Electrical Engineering	10,722.34
Civil Engineering	5,000.00
*Mining Engineering	1,850.00
Descriptive Geometry and Drawing...	250.00
General Equipment and Furniture....	5,344.98
Total	**$226,797.44**

The State Board of Education in their recent biennial report listed the inventory of the College of Applied Science at $201,000.00.

The corresponding inventory of the engineering plant at the Iowa State College, which has been built up gradually through the years, would be:

BUILDINGS.

Engineering Hall (with new tile roof)	$197,786.00	(a)
Structural and Hydraulic Laboratory..	25,000.00	
Pattern Shop	6,000.00	
Forge Shop	4,500.00	
Foundry	4,500.00	
Machine Shop	18,000.00	
Engineering Annex	35,750.00	
Ceramics Building	16,268.89	
Agricultural Engineering Building ..	100,000.00	(b)
Mechanical Engineering Laboratory...	50,000.00	(c)

(*Mining Engineering course discontinued.—Editor.)

(*a*) In this inventory no deduction is made for Physics. The Board has had plans drawn for a new Physics Building, which will probably be available in three years. This department now occupies temporary quarters in the Engineering Hall belonging to the regular engineering departments. The Physics Department teaches all work in Illuminating Engineering, and considerable other work that is given in the Electrical Engneering departments of other institutions. Four engineering departments are now anxiously waiting for the space it occupies, temporary use of which is allowed it in return for the engineering instruction given. The floor space occupied for Physics work is 14% of the total in the building, and 14% of the total cost would be $27,680.

(*b*) The Agricultural Engineering building is properly included in this inventory. This is agreed to by the Dean of Agriculture and the Professor of Agricultural Engineering. The work done in it is engineering work, requiring surveying linstruments, drafting rooms, shop equipment, gasoline motors, and machinery.

(*c*) The building in which the mechanical engineering laboratory work was formerly conducted for 21 years has been torn down for the construction of this building which is now under way. The funds for its construction have been appropriated for two years, and should be included in this inventory.

FURNISHINGS (Including some equipment).

Agricultural Engineering	$ 3,332.66 (d)
Civil Engineering	8,453.80
Engineering Hall (general furniture).	4,743.20
Electrical Engineering	1,831.14
Good Roads	220.63
Mechanical Engineering	5,857.14
Mining Engineering	7,331.22
Engineering Experiment Station......	118.50

EQUIPMENT AND SUPPLIES.

Agricultural Engineering	$ 7,110.55 (e)
Civil Engineering	13,875.63
Electrical Engineering	17,663.86
Engineering Dean	845.00
Engineering Experiment Station......	5,384.36
Good Roads	6,672.59
Mechanical Engineering	44,721.02
Mining Engineering	14,280.84
Engineering Library	25,000.00 (f)
New Equipment not listed separately..	11,875.22
Total	$637,122.25

The Student Central Committee of the State University of Iowa also includes $37,000 in the engineering inventory as the valuation of a hydro-electric installation on the Iowa River at that point. In successful working hydraulic laboratories it is found necessary to provide water in quite large volumes at considerably higher heads than are available with the low dam at Iowa City, and for this purpose centrifugal pumps of large capacity are generally provided, for which power is supplied at small cost, since they are seldom run, from the Central Power Plant. Hence, if auxiliary equipment available for experimental purposes is to be included, mention should also be made of the Central Heating and Power Plant at the University.

Corresponding auxiliary equipment at the Iowa State College, available and used for experimental purposes, would include the following:

(d) (e) This includes surveying instruments, shop equipment, drafting equipment, motors, etc. In addition twenty-five thousand dollars worth of agricultural machinery is loaned to the department by the large implement companies, and renewed from time to time for demonstration purposes. This is not the property of the College, and is not listed herein.

(f) This is the engineering library of 6,000 volumes which is located in Engineering Hall as an entirely separate department of the General Library. The estimate of its value is by the regular College Librarian.

Central Heating Plant, used by mechanical, electrical and mining engineering students for experimental work on boilers, engines, pumps, heating and ventilating, fuel tests, etc.	$120,448.10
Water Works Department, for use of all students in water supply engineering, and for special experimental work on pumps, storage reservoirs, elevated tanks, efficiency of nozzles of various sizes, pressures from hydrants at various heads, etc. Supplies water for the Hydraulic Laboratory..	50,980.36
Electric Lighting System, for use of electrical engineering students for many tests along their special line of work	11,879.96
Heating Tunnels, used for experiments on loss of heat for various distances, efficiency of steam pipe coverings, underground surveying, etc.	56,562.32
Sewage Disposal Plant, and Sewerage System, used by students in sanitary engineering	17,136.89
Gas Mains, for the application of theory to practice in the transmission of gas through pipes, etc..	1,757.98
	$258,765.61

If its proportionate share in the general buildings and equipment were added to the valuation of the engineering plant and its auxiliary equipment, the total valuation at Ames would exceed one million dollars.

CLOSE ASSOCIATION OF ENGINEERING AND AGRICULTURAL EDUCATION.

At the State College the courses in engineering and agriculture have been developed from the same base. The fundamental scientific courses are practically the same, and have been built up and strengthened for the proper instruction of the technical students. This is utterly impossible in any institution where the main object is not the grounding of students in the fundamentals preparatory to taking up their technical work. For this reason the science courses at the State College are not of the same character as at the University, where they serve more properly the students enrolled in the liberal arts college. There the number of engineering students is small, and their much larger enrollment from other colleges makes it necessary to shape the courses of study accordingly.

Agricultural attendance at the State College has long been in

the majority. Table IV and Diagram II show the relative attendance of agricultural and engineering students at the state schools since 1892.

TABLE IV.

RELATIVE ATTENDANCE IN AGRICULTURE AND ENGINEERING.

Year	4-Year Agriculture I. S. C.*	Total Agriculture I. S. C.*	** Engineering S. U. I.	** Engineering I. S. C.	*** Total Engineering
1892-93	78	112	50	179	229
1893-94	110	190	50	158	208
1894-95	131	205	48	147	195
1895-96	105	153	38	144	182
1896-97	101	148	41	135	176
1897-98	118	184	32	137	169
1898-99	209	329	31	193	224
1899-00	208	359	45	210	255
1900-01	258	550	51	304	355
1901-02	245	620	----------	309	309
1902-03	288	954	69	441	510
1903-04	334	915	78	503	581
1904-05	340	892	74	531	605
1905-06	341	1,125	162	570	732
1906-07	440	1,226	230	592	822
1907-08	474	1,133	249	704	953
1908-09	540	1,365	243	681	924
1909-10	589	1,216	218	602	820
1910-11	552	1,296	180	623	803
1911-12	647	1,449	165	587	752
1912	769	1,586	168	585	753

On the Diagram the total engineers, state educated, are obtained by adding together those at the State College and at the State University. These data furnish absolute evidence that at the State College agriculture and engineering have prospered wonderfully side by side, practically in proportion to the demand of the State for such instruction. It shows that the total attendance in agriculture is far greater than the combined enrollment of engineering students. This would be expected as the response to the natural demands of an agricultural state.

An investigation of the records at the State College will show practically the same relative support for agricultural and engineering instruction. The engineering budget for 1912-13 is as follows:

*Including Engineering Students with reference to Agriculture.
**Including students in Chemistry, taking no engineering.
***Including both students in Chemistry, and engineering students with reference to agriculture.

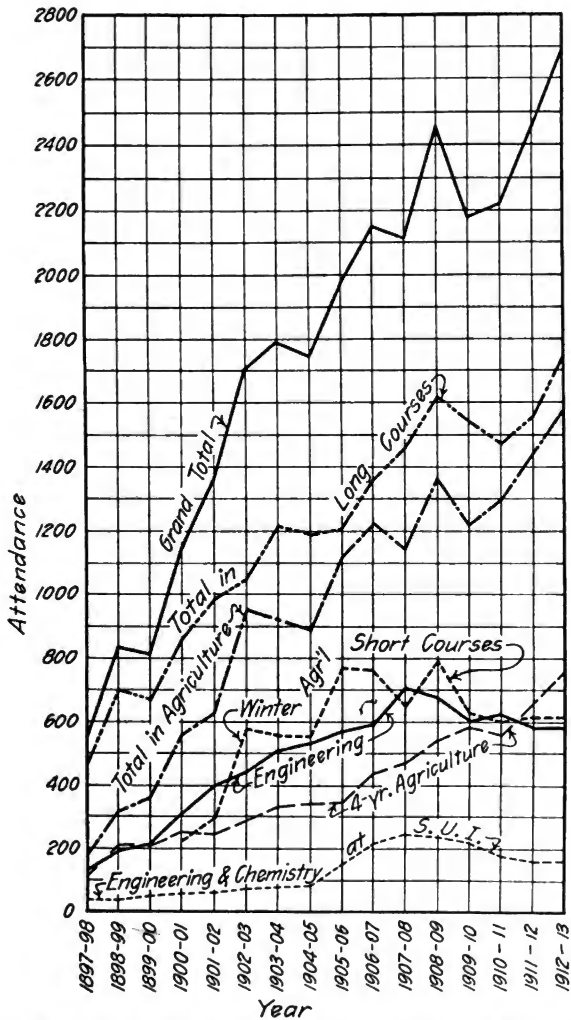

Diagram II. Relative attendance of Agricultural and Engineering students as the State Schools since 1892.

Agricultural Engineering—		
Salaries	$ 7,640.00	
Department Expenses	1,100.00	$ 8,740.00
Civil Engineering—		
Salaries	14,050.00	
Department Expenses	1,000.00	15,050.00
Electrical Engineering—		
Salaries	7,450.00	
Department Expenses	700.00	8,150.00
Engineering Dean—		
Salaries	1,500.00	
Department Expenses	1,400.00	2,900.00
Mechanical Engineering—		
Salaries	20,225.00	
Department Expenses	1,700.00	21,925.00
Mining Engineering—		
Salaries	9,075.00	
Department Expenses	1,200.00	10,275.00
Total Salaries and Department Expenses		$67,040.00
Engineering Experiment Station		10,000.00
		$77,040.00

The corresponding summary for the Division of Agriculture would be:

Salaries and Department Expenses	$ 82,930.00
Agricultural Experiment Station	85,000.00
Agricultural Extension	50,000.00
	$217,930.00

The inventoried valuation of the agricultural plant at the State College is also much greater than that in engineering.

In view of the foregoing, no one can rightfully say that Iowa is neglecting the education of her agriculturists, and laying too much emphasis upon the training of men for the industrial pursuits. The work of the College is being developed in proportion to the demand for each kind of instruction. Only so can a healthy, solid development be attained and maintained.

PLANS FOR ENGINEERING EDUCATION IN IOWA.

The State Board of Education, in its report to the Governor which has just been made public, makes possible a comprehensive plan for the Division of Engineering at the Iowa State College in carrying mechanics arts instruction to all parts of the great State of Iowa. Such a plan is discussed fully elsewhere.

Already the Agricultural Division is doing great work through its Extension Department in teaching the youth and adults of the State something of "how to farm." During 1911 they had enrolled, in addition to the students at Ames, about 25,000 youth and adults in their short course and correspondence study work. They also reached over 156,000 people through the medium of meetings, printed literature, etc. Work in agriculture is being established in the public schools all over the State, and everything possible is being done to carry the knowledge of scientific agriculture to every rural home in Iowa.

Add to this, engineering extension work and correspondence study, available for every youth and adult workman in the shops of our towns and cities to train them for greater efficiency in their pursuits without depriving them of their means of livelihood, and Iowa has taken a long step toward attaining a symmetrical development.

Iowa now ranks among the first of the agricultural states of the Union. She is just on the eve of a great manufacturing development which will raise her standing still higher among the states. Such a development is necessary to provide employment for the men who are turning from the rural communities to the towns and cities in search for work. It will also provide a market for the products of the fields, and keep within our borders millions of dollars now sent to other states for articles which can be manufactured as cheaply in Iowa.

In this great work the industrial and agricultural interests must work together, and a great technical school of engineering and agriculture at Ames, carrying the necessary instruction into the homes, the fields and the shops all over the State, will be a large factor in bringing about the symmetrical development which Iowa needs now to maintain and increase her supremacy among the states of the Union.

CONTENTS

Machine Shop, American Bridge Co., Toledo, Ohio. M. J. Riggs, B. C. E. '83, Superintendent

THE IOWA ENGINEER

VOL. XIII. FEBRUARY, 1913 NO. 5.

Storage Battery Operation and Maintenance

CHARLES A. HOBEIN B. S. E. E. '03.*

This article will deal specifically with operation and maintenance work in connection with two large storage batteries, installed by the United Railways Company of St. Louis, in 1903, rather than with storage battery work in general. The writer was in the employ of the company at the time these batteries were installed and continued in such employ for a period covering the useful life of most of the parts of the batteries. During most of this time the operation and maintenance of the batteries were under his supervision.

BATTERY ROOMS.

Both batteries were installed in the same location, a substation near the center of the railway load of the business district. The substation also contained eight thousand kilowatts in rotary converters.

The batteries were built and installed by the Electric Storage Battery Company of Philadelphia. Each battery had a capacity of 2,500 ampere hours at the one hour rate. By the means of series boosters it was possible to obtain a combined discharge of 5,000 amperes for one hour.

The battery rooms were contained on two floors. Both floors were below the ground level. Each floor was divided through its length into two rooms, by a concrete wall five feet thick. This wall supported the rotary converters. The wall was cut by a series of ten arches which made the battery rooms on each floor practically one large room. Each room was about

*Engineering Inspector and Statistian, Bond House of John Nickerson, Jr., St. Louis, Mo.

twenty-five feet wide and one hundred and sixty feet long. Each floor contained one-half of each battery. A battery consisted of two hundred and fifty-eight cells.

ORIGINAL CONSTRUCTION.

This battery installation being for railway use necessitated that one side be connected to the ground return.

Each tank which held the cell elements was made of wood, yellow pine being that best adapted to the purpose. Figure 1

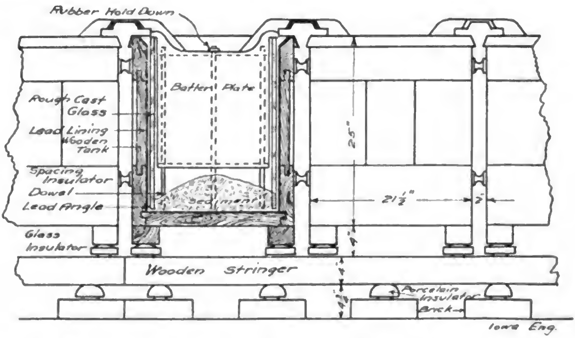

Fig. 1.—Original Battery Construction, United Railway Co.

indicates the manner of supporting the tanks. The tank shown in section illustrates the construction of the cell. The tanks were twenty-one and one-half inches wide by six feet one inch long and twenty-five inches high, outside measurement. As shown, the support under the cells consisted of wooden stringers supported on porcelain insulators. These insulators were in turn placed upon vitrified brick. There were five wooden stringers running under each cell. They were cross connected at suitable intervals with wooden tie pieces. This wooden structure was divided into units which extended under five cells. Thus every five cells was a section so far as the supporting structure was concerned.

It will be noted that the porcelain insulators were spaced with no particular regard to the width of the cells, thus it occasionally occurred that a row of these insulators came directly

under the space between cells. This brought these particular insulators where acid, which might collect on the edge of the overlapping lead lining, would drop upon them and destroy their insulating properties.

Each tank is directly supported by two skids running under its length. These are in turn supported on small glass insulators which rest on the skids previously described. There were five of these glass insulators under each skid or ten for each cell. Note the panel construction of the wooden tanks. The defects of this construction will be referred to later.

Each tank was completely lined with four pound lead, i. e., lead weighing four pounds per square foot. This gives a thickness of slightly more than one-sixteenth of an inch. All seams were burned together so as to make an absolutely homogenious lining. It will be noted that the lead lining extends over the edges of the tanks to protect them from the action of the acid electrolyte. The lead burning process will be described later.

Along each lower corner of the tank, inside the lining, was placed a one by one by one-quarter inch lead angle. This angle supported one glass plate which extended the full length of each side. These glasses formed the support for the battery plates, the battery plates being hung directly on them. The glass was the rough cast glass variety three-eighths of an inch thick.

Each tank contained seventy-seven plates, thirty-eight positives and thirty-nine negatives. The positives were Manchester type plates. The plate grid was lead, alloyed with other materials for stiffening. It contained two hundred eighty-eight three-quarter inch holes in which buttons were inserted containing the active material. The plates were about one-quarter of an inch thick and were formed by electrolytic action.

The negative plates consisted of a grid similar to the positives except the holes were one and one-half inch square. There were one hundred of these openings. Each hole was covered with an alloy screen, the space between the screens being filled with the active material, room being provided to care for expansion.

The plates were spaced five-eighths of an inch apart. This wood, treated to remove the wood acids. They are known as

board separators. Dowel pins five-eighths of an inch in diameter, split so as to slip over the board separator and long enough to rest on the bottom of the tank, held the boards in place. Strips of hard rubber bored with suitable holes were slipped over the ends of the center dowels, across the top of the plates, to keep the boards from floating out of position.

The plates were spaced five-eighths of an inch apart. This spacing together with the one-quarter inch width of each plate filled the tanks with the exception of a space of eight inches on each end. This end space proved very useful when it was necessary to clean the sediment from the tanks.

The electrolyte was dilute pure sulphuric acid of 1.210 specific gravity. This electrolyte while not particularly severe on the flesh of the arms and hands, is decidedly destructive to clothing and wood. The board separators can not be removed and reinstalled after having been once used.

On account of one side of the battery being grounded it was necessary to wear rubber shoes and rubber gloves when working on the cells. The voltage of the battery when charged was six hundred volts.

The tanks being of paneled construction it was necessary to brace them against one another by means of spacing insulators, to prevent bulging of the sides.

The pile of material shown in the bottom of the cell, marked "sediment," consists of active material, from the positive plates, and lead sulphate thrown down by the charging and discharging action. This material must be removed from time to time before it has an opportunity to pile up and short circuit the plates. The process of removal will be described later.

It will be noted that between each cell is a heavy lead channel bus bar. This had burned onto it all the negative plates in one cell and all the positive plates in the next. This made the connection between cells.

INSTALLATION.

One battery was installed and operated before the other was completed. The tanks were first installed and lined up. A following crew placed the plates in the cells. Then came the lead burners burning the plates onto the lead buses, between the cells. No electrolyte was installed until all the cells of one

battery were installed. This work usually proceeds uninterruptedly. Occasionally the lead burners are affected with lead poisoning, which causes severe colic, and is sometimes fatal. This trouble is caused by inhaling the lead fumes too continuously.

For installing the electrolyte a lead lined tank was placed in the street above, at wagon level and a platform erected around it. The electrolyte was hauled in large carboys of glass and emptied into the tank. It was siphoned from the tank and the cells filled through rubber hose.

After the cells were filled it was necessary to give the battery an initial charge of about twenty hours at a very low rate, about five or six hundred amperes. The positive plates were not shipped in an entirely charged condition. The negatives also needed some charge to soften them and make them active.

The boosters did not arrive for some months after the batteries were installed so the charging was done by a steam driven booster running in a power plant several miles distant.

The substation was not in operation when the batteries were completed. Power was badly needed. The batteries were connected to a temporary bus bar and during the evening peak, for several months, enough trolley sections were carried on the bus to load the batteries to their capacity. The service was very severe. Often the batteries would be discharged to such a point that incandescent lamps connected on the circuit would hardly show a red glow, meaning perhaps 250 volts on the batteries.

EARLY OPERATION.

During the first few years the batteries did not require many repairs. The main duty of the operator consisted of taking care of the evaporation by filling the cells twice a week with distilled water and washing the floor, with a hose, once a month.

The distilled water was hauled to the station in a tank wagon from one of the power stations. The water was condensed steam from the surface condensers of steam turbines. During the summer the evaporation amounted to about six wagon loads per week or four thousand gallons.

The floors of the battery rooms were constructed of vitrified brick set on edge on concrete. The interstices were filled with pitch. After the floor would be washed it would be covered with soda ash to neutralize any acid and help dry it. Sulphuric acid is hygroscopic. Another method used with some success was to dissolve soda ash in water and spray the wooden tanks to neutralize any acid which might crawl over from the inside of the cell. This was done of course to stay the progress of decay which the acid caused.

BOOSTERS.

The boosters were motor driven, separately excited, having a six hundred volt winding on the fields. They were capable of boosting 2,500 amperes, 150 volts. They were connected between the ground return and the negative side of the batteries. When a battery was near the end of its discharge, the booster motor took about seven hundred amperes at six hundred volts. One might be misled into thinking the power absorbed by the booster motor was lost. It is easily seen, however, that the only loss which occurs is the loss measured by the efficiency of the booster sets.

BOOSTER RHEOSTATS.

An ingenious device in connection with the boosters was the method of constructing and connecting the field rheostats. By means of these devices the boosters could be reversed, in polarity, without opening the circuit. (For diagram of connections see Lamar Lyndon's "Storage Battery Engineering", page 302, first edition.) By means of these rheostats the batteries were under perfect control, when connected in parallel with the rotary converters. The batteries could be made to charge, discharge or remain floating on the bus by simply manipulating the rheostat handles.

FIRST REPAIRS.

The batteries consisting of such a number of cells, and one side of each battery being grounded, made it difficult to maintain perfect insulation. There were so many insulators in parallel to reduce the insulation resistance.

The first repair job was occasioned by a leaky cell. This leak occurred during the first year the batteries were installed. This

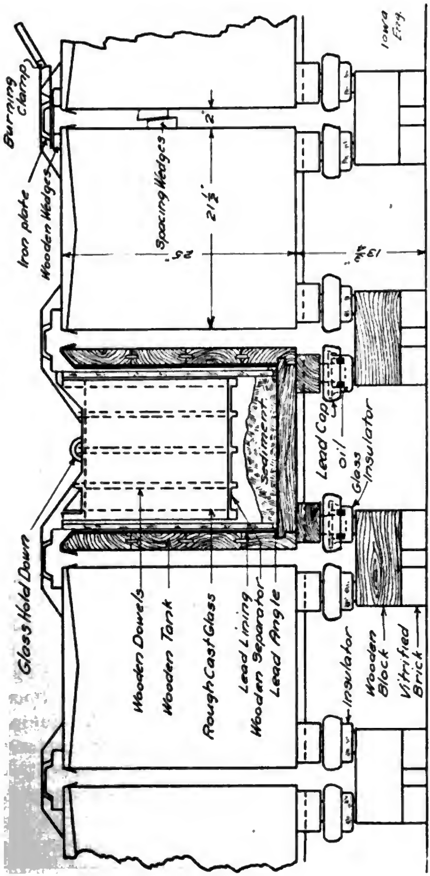

Fig. 2.—Type of Construction used on New Battery Installation, United Railways Co.

was only the beginning of similar trouble which became more serious as the batteries became older. At times leaky cells became serious propositions.

One cause of leaky cells was found to be due to the method of ventilation. Air was forced into the room through ducts which discharged near the floor. The air coming into the room carried dirt which deposited on the nearby cell insulators. This quickly destroyed the insulating properties of the porcelain, current began to leak to the ground and electrolysis to eat holes in the lead lining of the cells. The air ducts were changed so the air entered over the tops of the cells. A better method of ventilation is to induce the fumes to leave by means of induced draft fans.

REPAIRING LEAKY CELLS.

In repairing a leaky cell it is first necessary to siphon out the electrolyte. This weighs 900 pounds and requires seven carboys to contain it. The plates are next cut away from the lead busses between cells. This is done with large lever cutters and requires but several minutes of time. The positive plates are piled on the floor as they are not injured by drying. The negatives are distributed in nearby cells in the space left in the ends of the cells. The negatives must be kept wet. The board separators are thrown in a receptacle together with the sediment from the bottom of the tank. At first the leaks were repaired with the cell remaining in place but after several repairs were made only to have the cell develop a leak a few days after the repairs were completed, the tanks were removed to an upper floor. Here the tank was reversed over a wooden form which just fitted the interior of the lead lining and the lining was then separated from the tank. It was thus possible to examine the entire outside surface of the lining. When electrolysis is bad there are very often many holes partially eaten through the lining which would soon cause trouble. It is necessary to cut away large areas of the lining and burn in new patches.

LEAD BURNING.

For burning lead, hydrogen gas is used mixed with air. This gives an intensely hot flame. For sheet lead burning considerable skill is required. The patch is inserted in the hole and

the edges scraped clean. Then the operator takes the torch, with a needle point flame, in one hand and a stick of lead in the other and proceeds to fill the seam by the process of amalgamating the two. In burning the plates onto the bus bars, when installing the battery, a larger flame is used and the process requires less skill. After the patch is completed the lining is replaced in the tank. The tank is then filled with water for test. If the test is satisfactory the tank is replaced in the battery, the plates burned in, acid replaced, new separators in-

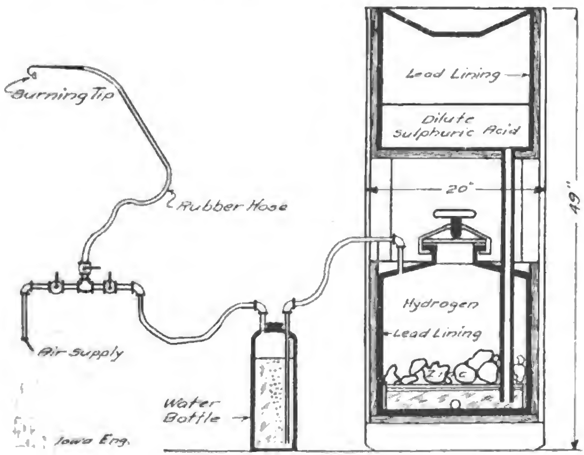

Fig. 3.—Hydrogen Generator used for Lead Burning

stalled and it is given an individual charge to restore the plates to an active condition.

Figure 3 is a cross section of the type of portable hydrogen generator used. The upper receptacle contains sulphuric acid of strength known as Oil of Vitriol. The solution is made by mixing one part of oil of vitriol to four parts of water. Zinc is put into the lower receptacle and held above the level of the bottom of the pipe leading from the upper vessel, by a perforated table. The acid runs into the lower vessel and attack-

ing the zinc forms zinc sulphate and sets hydrogen free. This process continues until enough pressure is formed to force the acid up the pipe into the upper vessel and away from the zinc. This stops the formation of hydrogen until, through use, the pressure again falls.

The gas is conducted to a safety water bottle and to the point of use through rubber tubing. Air is pumped to the burning tip by means of a car type air compressor. The compressor is reduced in speed by connecting the six hundred volt motor across about six cells of the battery.

For giving a cell an individual charge wires, which connect with the boosters through a special switchboard, are used. The boosters can be regulated to give a voltage suitable for charging one cell, about two volts. The charge is given at about a six hundred ampere rate and continued until the specific gravity reaches the correct value.

In figure 2 the method of burning in the plates is illustrated. In the upper right hand corner, it will be noted, a burning clamp is shown installed. When the plates are cut out they are cut so as to leave the triangular space, shown in black, inside the clamp when it is fitted up against the bus bar between cells. An iron plate is wedged up under the bus bar, as shown, to support the clamps and form the under side of the mould. An assistant places the clamps on the plates in succession. It is not necessary to have more than six clamps as the lead cools very quickly. The burner simply melts bus bar, plate, and lead strip so they run together and amalgamate filling the triangular space as shown. The clamps are dipped in powdered soap stone, so as to prevent them from sticking to the plates. The plates can be burned in, in about one hour by a good burner, i. e., a cell of 77 plates.

CHANGE IN SPECIFIC GRAVITY.

As time passes the electrolyte in the batteries becomes lower in gravity regardless of the amount of charging which is given it. It then becomes necessary to add sufficient additional fresh electrolyte to maintain the battery at the proper point. The gravity of the battery when first installed and in a fully charged condition was 1.210. The battery people now recom-

mend a lower gravity for these batteries and they are maintained at about 1.165 specific gravity.

It is important to have the batteries fully charged before attempting to put in fresh electrolyte. The cells must also be given an overcharge once per week for several days in order to stir up the electrolyte in the cell and have the plates in a fully charged condition. If all the lead sulphate is converted to sulphuric acid by the charging, more acid than is necessary will not be added to bring the gravity to the proper point.

TROUBLE WITH REVERSED CELLS.

Much trouble was encountered at one time on account of not taking the proper precautions when adding fresh acid to restore the electrolyte to the proper gravity. Many of the cells became reversed in polarity. When the battery was discharging these reversed cells would be charging as shown by severe gassing and voltmeter readings. The remedy was to reduce the gravity and give each cell an individual overcharge with the polarity in the right direction.

RECONSTRUCTION.

In the early summer of 1910 work of reconstructing the batteries was commenced. By this time (six and one-half years after installation) the positive plates were so nearly worn out that the batteries were very low both in capacity and efficiency. The wooden tanks were badly decayed by the acid, as were also the wooden stringers under the cells. The batteries were badly grounded. Five or six leaky cells were needing attention all the time.

The Railways Company decided to do the reconstruction work themselves. Reference to figure 2 will indicate the improved construction employed.

Each cell, it will be seen, is an independent unit. Wooden blocks resting on bricks form the support for the insulators. There are ten of these blocks and insulators under each tank, five under each side. The space under the cell is perfectly clear. A man can crawl under the cell and replace any insulator or block.

The battery company had developed a new oil insulator which was used. This is shown. The oil is contained in an an-

nular space in the insulator, (shown in black in the drawing). The whole is covered with an alloy cap. Any leakage would have to come down the center extension of the insulator across the surface of the oil and thus to ground. After two years' service the insulation is almost perfect.

New tanks were made and installed. They were solid and patterned after the present tank used by the battery company. The new tanks being without panelling were much stronger and did not require so many spacing insulators. The panelling of the old type tanks was so constructed as to form a lodging place for acid drips and the consequence was decay in the crevices.

The old tanks were removed to an upper floor, the lead lining removed, and after the lining had been inspected inside and out and repairs made if needed, the lining was installed in the new tank. All the old linings with a few exceptions were used over again.

The lead linings where they extend over the edge of the tanks were cut to form drip points. (See figure 2.) The point on each end was in the center and on the sides there were four points which came between the insulator spacing of the tanks. This scheme keeps the insulators free of acid from the dripping.

A new type of positive plate was used known as the Tudor type. The new positives were practically pure lead plates, grid and active material. The plates were about three-eighths of an inch thick. The surface was cut into horizontal rows of finely divided grooves. Between the three-eights inch wide horizontal rows was left a webb of the lead which was not cut. The active material was formed in the finely divided grooves. These plates were very easily buckled and required very rigid separation. The board separators were equipped with five dowels each. The outside dowels were an inch wide by one-half inch thick. The other three were one-half inch wide by one-half inch thick. These separators were suspended from the top of the plates by means of a rubber peg pushed through the top of the center dowel. The hold downs were semicircular glass pieces about eight inches long. Some of the old plates, removed in the process of reconstruction, did not have any of

the active material remaining in them. Enough were found, however, to be sufficiently valuable to give a year's service in fifty cells.

The negative plates, still in use, were the plates from the original installation. They were apparently good for several years more of efficient service.

TESTS.

Some wattmeter tests were made on one of the batteries before and after the reconstruction. The following figures were obtained. The weekly overcharge was distributed and charged to the amount of energy put into the battery, by adding one-sixth of the power required by the overcharge, to the charge required by the battery, after a discharge, if a discharge occurred on six nights of a week following the overcharge:

BEFORE REBUILDING.

	One week's average
Kilowatt hour efficiency	32.1 per cent
Ampere hour efficiency	45.3 per cent
Capacity discharge ampere hour	960

AFTER REBUILDING.

	One week's average
Kilowatt hour efficiency	43.8 per cent
Ampere hour efficiency	51.3 per cent
Capacity discharge ampere hour	2410

COSTS.

Two batteries installed complete with boosters, wiring, switchboards, and copper bars	$198,000.00
Cleaning out sediment, including pump, tanks, etc.	2,223.13
Reconstruction 1910 and 1911	107,321.88
Board separators complete with dowels, each	0.15
Positive plates, each	4.00
Negative plates, each	3.65
Oil insulators complete wih alloy cap, each	.40
Wooden tanks, railway company's manufacture, each	12.00
Lead linings, railway company's manufacture, each	15.00

The Rational use of Water in Irrigation*

DR. JOHN A. WIDSTOE
President Agricultural College of Utah

To all who have dipped ever so little into the history of irrigation, the annual meetings of this Congress appear of great importance. Irrigation is one of the great world-movements for subduing the "waste places" of the earth, and also for solving many of the social problems that perplex mankind. It is not impossible that upon irrigated lands, with their possible small family units, and their fertile soils and abundant sunshine, shall be formulated by actual experience the social ideals that eventually may bring the nations with their legions of human hearts into co-operative peace. This Congress is the only organized body which assumes general interest in all the methods, purposes and results of irrigation. Its annual meetings, therefore, if soberly conducted, should be milestones of an important phase of human progress. For that reason I venture to present to you a matter of high importance in the establishment of irrigation.

From its humble beginning in this city, modern American irrigation has grown, until, the census of 1909 reports nearly 14,000,000 acres of irrigated lands. One-half of this vast area was brought under irrigation since 1899, and three-fourths since 1889. That is to say, during the last twenty years, three-fourths of the irrigated lands were reclaimed; while only one-fourth was brought under irrigation during the first forty-two years after the entrance of the Utah pioneers into the Great Salt Lake Valley. Clearly, the efforts of the country in behalf of irrigation have increased in geometrical ratio. This interest appears to continue undiminished, so that it can only be a matter of comparatively short time until most of the irrigation waters of the West shall have been brought upon the lands.

*Address before the Twentieth National Irrigation Congress, Salt Lake City, Utah Sept. 30-Oct. 3, 1912.

There are three main stages in the development of an irrigation project. First, the construction of satisfactory dams and canals in which the water may be stored and then led upon the land; second, the settlement upon the reclaimed land of a sufficient number of people to make full use of the opportunities of the project, and, third, the correct use, by the settlers, of the water and land so that the project may be highly and permanently profitable. While these three stages are of equal necessary importance, yet it is evident that the first two, construction and settlement, once accomplished are practically forever done, but the third, the use of the water, is of annual recurrence and in the end will determine the success or failure of the project.

This third stage, the use of water, has been given least systematic attention; but with the increasing population under irrigation, it is insistently clamoring for attention. In the arid and semi-arid region, irrigation, under present methods of use, can probably never reclaim more than one-tenth to one-fifth of the total area of tillable land. For our 14,000,000 acres of irrigated land there are at least 500,000,000 acres that must be reclaimed, if reclaimed at all, by other methods. There will always be more land than water in the arid region; and one of the chief concerns of every project should be to cover profitably the largest possible area. The actuating spirit of irrigation enterprise is, or should be, to make possible happy homes for the many.

With this thought in mind let me call your attention to two vital principles of irrigation success. First, the beginning of irrigation wisdom is the conservation of the natural precipitation, i. e. the rain and the snow. Irrigation is not a primary art; it should always be supplementary to the natural precipitation and should only make up for the deficiency in the rainfall. The progress of dry-farming during the last decade has brought this truth home to the irrigated section. The water which falls from the heavens, even under an annual precipitation of 10 inches, is amply sufficient to produce crops, could it only be fully held in the soil. By properly conserving the rain and snow-water in the soil by dry-farming methods, large crops may be grown with small quantities of irrigation water. This

is well brought out in a series of experiments conducted during the last ten years at the Utah Experiment Station.

Table No. 1—The Crop Producing Power of the Natural Precipitation

YIELDS PER ACRE	Inches of Irrigation Water Used		Per cent of yield due to Rainfall
	None	5.0 to 7.5	
Wheat (bu. of grain).....	39	47	84%
Oats (bu. of grain).......	55	64	86%
Corn (bu. of grain)......	44	54	81%
Wheat (pounds of straw)..	3934	4526	86%
Oats (pounds of straw)...	2233	2274	98%
Corn (pounds of stover)..	3228	3888	83%
Alfalfa (tons of hay)......	5540	7178	77%
Potatoes (bushels)........	97	145	67%

The data in the above table show that approximately 85% of the yields, under irrigation conditions, of wheat, oats and barley, 77% of the yield of alfalfa and 67% of the yield of potatoes, was due to the natural precipitation stored in the soil. This is only a fair sample of what may be done on any irrigated farm if careful soil tillage be practiced. If, now, by careful tillage the natural water had been allowed to escape into the air, much more irrigation water would have been required to produce the crops. By the proper storage of the rain and snowfall in the soil, alone, it is possible to extend our irrigated 14,000,000 acres considerably. Therefore, to make our irrigation projects of greatest service, the settlers upon them must be taught that irrigation is designed only to supplement the natural precipitation.

Second, the yield of any crop under irrigation is not in proportion to the quantity of water applied. The more water is used in irrigating a crop, the less yield is obtained per unit of water. This has been amply demonstrated also in the long continued investigations at the Utah Station, already referred to.

As examples note the following results obtained with wheat and sugar beets:

Table No. 2—Inches of Irrigation Water Applied

	5	10	15	20	30	50
Wheat(bu. grain per acre).........	38	44	46	47	49	49
Wheat (lbs. straw per acre)........	2986	3452	3954	4311	4755	5332
Sugar Beets (tons per acre)........	14	19	20	21	21	24
Wheat (bu. grain per acre-inch) ...	7.56	4.35	3.05	1.86	1.39	0.99
Wheat (lbs. straw per acre-inch)...	597	345	264	172	136	107
Sugar Beets (tons per acre-inch)....	2.76	1.86	1.30	1.06	0.69	0.49

As the water increases, the yield becomes relatively smaller, and if enough water is applied, there is an actual diminution of yield. The studies of the United States Irrigation Investigations under Drs. Mead and Fortier have shown that excessively large quantities of irrigation water are used in ordinary practice. The losses which the irrigated section has thereby sustained will probably never be known, but unquestionably run annually into millions of dollars.

It is of higher importance than ever before that a reasonable duty of water be established, and that those responsible for irrigation projects, by the education of the farmers as well as by the enforcement of reasonable rules, see to it that such duty is observed. At present, the duty of water assigned by the State Engineers is seldom as low as 30 acre-inches; usually much higher. It will be a living question, in view of what we are learning concerning the relation between water and crops, whether even 30 acre-inches shall be allowed for one acre of land when it might be made to accomplish so much more if spread over a larger area.

Spreading 30 acre-inches of water over four instead of one acre, the increase in yield for wheat, corn, sugar beets and potatoes was three-fold; for alfalfa even more, and for timothy twofold. Increasing foodstuffs in this manner, two and three-

fold, simply means that from two to three times as many human beings may be maintained upon the irrigated area; and every lover of the West dreams of the day when populous commonwealths shall cover the "Great American Desert." Irrigation is for the many, not for the few.

Table No. 3—The Crop Producing Power of 30 Acre-inches When Applied to Different Areas of Land

CROP	30 Acre—inches spread over			
	1 acre	2 acres	3 acres	4 acres
Wheat (bu. of grain)......	48	91	132	166
Corn (bu. of grain)........	97	188	269	317
Wheat (pounds of straw)...	4533	7908	10356	13204
Corn (pounds of stover)....	.0390	16558	18021	28756
Timothy (pounds of hay)..	6054	7688	11739	11928
Alfalfa (pounds of hay)....	8840	15093	29653	....
Sugar Beets (tons).........	21	39	56	65
Potatoes (bushels).........	195	373	456	544

By a more intelligent use of the waters already impounded or diverted the irrigated area may be increased largely, perhaps doubled. It is certainly a subject worthy of consideration. True, under the new projects, not yet well settled, there is no scarcity of water; yet in developing the West by irrigation should not the growth be symmetrical? We hope that no completed project will long remain without settlers; should we not be equally anxious that every new settler, from the beginning, use water the right way. In our older sections, water already is scarce; methods for increasing the duty are sought after; in time the newer sections will be in the same condition. Let us learn good habits in our youth, so that we shall have less to unlearn in our maturity.

Much more might be said upon this subject.

Many principles have been developed for increasing the economical use of water, such as top cultivation and the mainten-

ance of soil fertility. These should be taught persistently to the farmers, and Federal and State governments, as well as owners of irrigation projects, should urge and support a more complete investigation of the mutual relationship among soil, water and crops. Then we should sooner establish a science of irrigation agriculture.

Above all, however, the positive danger of using too much water an irrigation should be shouted over the land, until every citizen must know that the excessive use of irrigation water not only diminishes and injures crops, but that it is the greatest menace to the prosperity of the irrigated region. By such unwise irrigation ground-water rises and either limits or prevents crop production; soil fertility, accumulated through numberless years, is washed into the ground-water, away from the reach of roots, thus hastening the disastrous day of soil depletion. By the moderate use of irrigation the irrigated area may be immensely enlarged, the crops increased and the soil fertility conserved.

This is a fair subject for the consideration of our Engineers, Experiment Stations, legislators and National Irrigation Congress. The great work inaugurated 65 years ago in this city, fostered and made great by this Congress, is not for a day. It may be a miracle, but if worth while it must be a continuous miracle. Only by the proper use of the water on lands can it be made so.

Notes on the Testing of Fire Clays

M. F. Beecher, B. S. in Cer. '10 *

The term "fire clay" as it is generally interpreted has a very indefinite and elastic meaning. Usually it is applied to any clay which may be made up into wares that will withstand high temperature. This might mean any degree of heat from that attained in an open fire-place to that reached in a furnace for ore smelting. Obviously a clay suitable under the first set of conditions would not, in all probabilities, be suitable under the

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second. Fire-clays are frequently found associated with coal seams and in consequence miners invariably call any clay so associated a fire clay. In general this is far from the truth. The clay worker, at least, must have a more definite conception of the meaning of the term.

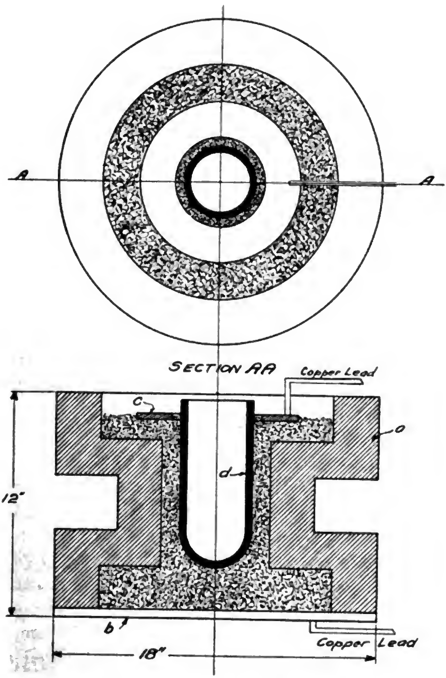
It is commonly accepted that the dividing line between refractory and non-refractory clays, as regards their temperatures of fusion, lies at or near 1650 degrees centigrade, although this cannot be taken as a safe criterion for classifying refractories. It can be safely said, however, that very few No. 1 fire brick are made from clays fusing below this point. Since a high fusion point is the prime essential, its' determination might well be made the first preliminary test.

The clay to be tested is moulded into a small "trial" the size and shape of a Seger cone (a tetrahedron or triangular pyramid about two inches high and measuring about half an inch at the base. This is placed in a vertical position on a fire-clay slab, lowered into a suitable furnace, and the temperature gradually raised until fusion has proceeded to such an extent that the sharp edges of the cone have assumed a rounded appearance and the tip has fallen over until it touches the base. The temperature at this point is recorded as the temperature of fusion.

At first this might appear as a very reliable index to the character of a clay, but upon carefully considering the facts this is found not to be the case. Clays, being mixtures of minerals rather than definite chemical compounds, have no well defined melting points. The change from the solid to the viscous state is very gradual, often extending over a period of several hundred degrees. If two clays are taken whose cones show the same temperature of fusion, it may occur that if an appreciable load be applied to each at temperatures approaching their fusion points, great difference will be noted in their failure temperatures. This is due to the difference in their periods of softening; the one having the longer softening period failing first.

To this end, a test of fire brick under load at high temperatures has been devised by Bleininger and Brown at the Pittsburgh Testing Laboratory. The furnace used for this work was of special design and is described by them in detail in Vol. XII

transactions A. C. S. It is fired by means of natural gas and compressed air and it is possible to bring the temperature up to 1350 degrees Centigrade in about five hours. The load is applied to the brick by a lever outside the furnace and is car-



Cross sectional view ot Carbon Resistance Furnace

ried to the brick through a high grade fire clay bar acting as a column. The lever is fitted with adjusting bolts by means of which it can at all times be kept in a horizontal position. The movement of the lever can be observed by the operator and is an index to the action of the brick under test. Their final re-

commendation is that the brick be placed on end under a load of 50 pounds per sq. in., and subjected to a temperature of 1350 degrees Centigrade for one hour. They further recommend that a one pound fire brick should show no other marked deformation than a shortening of not to exceed one inch in the total original length of nine inches.

Some objections might be raised to this test on the ground that the time factor at high temperature figures prominently in the failure of fire brick and that in this case the specimen is held at the maximum temperature for only one hour. On the whole, however, the test relatively approximates actual conditions of use and gives such consistent results that it is likely to become, in time, a standard test for fire brick.

The furnace used for making the actual fusions are of several different types. The "Carbon Resistance Furnace" is probably the most convenient and satisfactory of those in use. It is described by Coggeshall and Bleininger in Vol. X Trans. A. C. S. A cross-sectional view is shown in the sketch. The casing "a" is made from a high grade fire clay and is supported on a wrought iron plate "b". A wrought iron ring "c" and the crucible "d" complete the list of parts. The annular space between the crucible and casing is packed with carbon; a grade known commercially as "Electric Furnace Carbon". The electrical connections are made through the supporting plate "b" and the ring "c". The heat is generated by the resistance of the carbon to the flow of current. The current from the power line is stepped down through a suitable transformer so that it is available at five volt intervals from twenty to seventy volts. With this apparatus it is possible to get sufficiently high temperatures to fuse almost any clay. With the one in use in the Ceramics Laboratory of the Iowa State College, temperatures of over 3200 degrees Fah. have been obtained and this limit was determined only by the failure of the crucible by melting.

Methods for the testing of fire clays and fire clay products have not yet been standardized but considering the progress that is being made in Ceramics work, it should not be long before methods for systematic examination are available.

THE IOWA ENGINEER

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EDITORIAL

The extent to which storage batteries are being used for the supplying of electric current for light or power is perhaps not fully appreciated by many people. In the last decade there has been much advancement in storage battery construction. Their use in storing power for traction purposes has allowed a saving in operating expenses. In this issue, Mr. Charles Hobein, describes the maintenance and operation of the storage batteries used by the United Railways Co. of St. Louis. Cur-

rent from these batteries is used during periods of heaviest traffic, when the regular generators might be overtaxed. Mr. Hobein describes the construction of, and also some of the difficulties encountered in operating them. In repairing the cells some unique methods have to be employed. The article gives a clear idea of one kind of storage battery used for electric railway purposes.

Our readers are referred to the article on "The Rational Use of Water in Irrigation," by Dr. John A. Widtsoe, which appears in this issue. Besides furnishing valuable information to engineers interested in irrigation, it emphasizes the necessity on the part of every engineer of studying the economic results of any engineering work with which he is connected. The threefold increase in the productiveness of land which resulted from distributing a given amount of water over four acres instead of one might on first consideration seem unimportant to the engineer. When we realize that the increase in returns from the land was the justification for the engineering expenditure, we find the reason why the irrigation engineer must consider more than the construction of the dams, reservoirs and waterways. The same broad view of all factors is required in any branch of engineering.

Discussion over the road and bridge law in the legislature has centered itself somewhat about the matter of local or state control. The fact that a centralized authority is proving most efficient in nearly every other kind of public work goes to show that this is the proper method for highway matters also. To let each county or township solve its own road problem would be no change from the present inefficient system. The construction of all main roads first, built for the public as a whole, is the first logical step. The building of branch roads would then come naturally. To accomplish this township road roadsuperintendents, and county engineers, acting under a State Highway Commission, are necessary.

COLLEGE NOTES

C. S. Nichols and C. B. McCullough now have a bulletin ready for the printer which deals with the "Determination of Internal Temperature Range in Concrete Arch Bridges." This bulletin gives the results of tests made with both mercurial thermometers and electrical resistance coils and covering a period of three years. The data given show a temperature range of 80 degrees which leads the authors to recommend that this large range be allowed in designing concrete bridges.

The State Legislature has authorized the preparation of plans for a Transportation Building at I. S. C. The preliminary plans show a three-story building to contain a locomotive room, a museum for railway models, a locomotive testing room and an automobile testing room.

The Electrical Department has recently received and installed some new equipment including ten demonstration voltmeters, ammeters, and wattmeters. These are long scale instruments and are set in glass cases so that the operation of the mechanism is visible. They have also received two hundred telephone condensers for the study of capacity effects, and four new machines for testing purposes. These include a 10 H. P. G. E. synchronous motor, a Westinghouse 10 K. W. synchronous converter and three wire generator, and two Fort Wayne 5 K. W. synchronous converters.

The Mining Department has recently received a valuable addition to its collection of rocks and minerals in a shipment of two collections received from Germany. One of these collections consists of over 300 specimens of representative building materials, and the other contains 40 soil samples and over 500 thin specimens of rocks for microscopic study.

Prof. S. W. Beyer addressed the session of the Iowa Brick and Tile Association in Des Moines Jan. 23. He advocated short courses in brick and tile work and an extension department for the industry under the supervision of I. S. C. and asked the support of the Association in getting the proposition started.

R. W. Crum of the experiment station has made a visit to Chicago for the purpose of investigating the latest methods of manufacturing and testing cement.

The equipment of the Hydraulics Laboratory has been augmented by a new Union Pump Co.'s 6 inch centrifugal pump direct connected to a 20 H. P. induction motor.

IOWA NOTES

The Keokuk Water Co. have engaged Alvord & Burdick of Chicago to prepare plans for a new intake, a new sedimentation basin, and extensions to the mains in that city.

The contract has been awarded for the erection of a new plant for the Charles City Gas Engine Co. of Charles City.

Iowa City has authorized the laying of $17,000 worth of paving this year.

The Des Moines Hospital Association is planning to build a Homeopathic Hospital at an estimated cost of $100,000.

Local capital in Burlington has organized the Burlington Belt Line Co. for the purpose of building a railroad sixty-five miles in length to connect Burlington with Beardstown, Ill.

The school board at Keokuk has voted $50,000 in bonds for the erection of a new school building.

Sioux City has received bids for constructing a reinforced concrete reservoir 142 feet in diameter by 32 feet deep and enlarging the present reservoir to the same dimensions. The cost of these improvements will be nearly $50,000.

The city of Clinton has let the contract for sewer improvements to cost $20,400. Plans have also been prepared for the construction of a $500,000 municipal electric light plant.

The Rock Island Ry. is reported to be planning extensive improvements at Iowa Falls which will include an $80,000 station.

Plans have been made for a concrete bridge over the Maple River near Ida Grove which, with the approaches, will be 400 feet long.

ALUMNI NOTES

L. T. Gaylord, C. E., '04, recently passed through Ames and had a short talk with Dean Marston. Mr. Gaylord has entire charge of the operations of the Atlantic, Gulf & Pacific Dredging Co. At present he is engaged in building a ship canal from Houston, Texas, to the coast. The company has centered $600,000 worth of machinery at his place and is doing some remarkable work. Among the Ames men employed by this company are S. H. Ware, C. E., '09; C. V. Slater, C. E., '11; and P. V. Miller, E. E., '12.

Harry Kerr, C. E., who graduated at Christmas, has received a good position in the block signal department of the North-Western R. R. At present Mr. Kerr is located at Belle Plaine, Iowa.

F. W. Schreiber, C. E., '09, and F. A. Dragoun, C. E., '10, together with their wives, spent part of vacation at Ames. These men are making a success of general engineering work at Watertown, South Dakota.

H. E. Robinson, Min. E., '08, is now located at Contact, Nevada, sampling and reporting on a mining property there.

C. Shoemaker, M. E., '12, who has been draughting for the Hart Parr Co at Charles City, Iowa, has secured a good position with the Bradley Mfg. Co., at Kankakee, Ill.

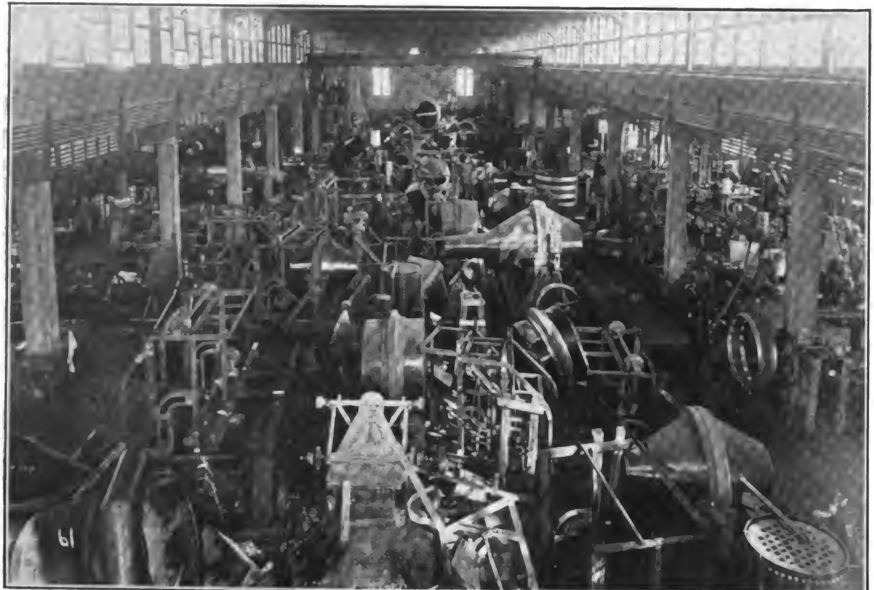
O. Negaard, M. E., who graduated at Christmas, is employed by the Tri-City Railway and Light Co. of Davenport. He reports his work as very interesting and is confident that he has a great educational opportunity before him in his new field.

M. L. King, M. E., '06, who was formerly experimentalist for the Agricultural Engineering Dept., has been appointed general manager for the Bradley Mfg. Co. at Kankakee, Ill. This company is a branch of Sears-Roebuck Co. and last year did over $2,000,000 worth of business.

B. L. Dorman, C. E., '09, is now city engineer of Vancouver, Wash.

Victor N. Friedman is with the Engineering Dept. of Union Electric Light and Power Co. of St. Louis, Mo. Address 4954 Washington street.

CONTENTS



Assemb'ing Room of the T. L. Smith Co., Milwaukee. The famous Smith Concrete Mixer was designed by Mr. Smith who graduated in Engineering from the Iowa State College in 1877

THE IOWA ENGINEER

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The Accuracy of Engineering Computations

BY F. A. FISH.*

There are practically no computations in engineering work which do not involve factors which have been obtained by taking the measure of some property of a material, or of a machine, or of space; and since there is always a limit to the accuracy with which measurements can be made, it follows that the accuracy of the result of any computation involving such measurements will depend upon the accuracy of the measurements.

It is not the purpose of this paper to enter into any detailed discussion concerning errors of measurement; its object is to call attention to a few points relative to the proper number of figures to use in making computations when the accuracy of the initial data is known or assumed. It is not uncommon, especially among students, to use many more figures than are necessary, and the time and energy consumed in carrying an excessive number of figures through a computation is generally worse than wasted because it adds nothing to the accuracy of the result and only increases the liability of making mistakes. It may not be necessary to mention it, but the word "errors" as used in this paper does not refer to mistakes in arithmetic, nor "accuracy" to the degree of freedom from such mistakes. To succeed at all, an engineer must be able to read instruments correctly and to execute computations without arithmetical errors. A paper might be written emphasizing most strongly the extreme importance of painstaking care in this matter, but it is

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not within the scope of this article to do more than call attention to it.

In the nature of things, instruments used in engineering work vary as to the degree of accuracy which they will give, and this variation depends not only upon the kind of instrument used but also upon the nature of the property which is being measured. The diameter of a test piece can be measured more accurately with a micrometer caliper than with an ordinary caliper and scale; but the tensile strength of the piece can not be measured to the same degree of accuracy as can the diameter. The resistance of an electric wire can be measured more precisely with a Wheatstone bridge than with a slide-wire bridge; but electromotive force can not be measured as accurately as can resistance. No measurement can be made with absolute accuracy; nor is it possible to give an absolute numerical expression to the error involved in a given measurement. Any expression given as the amount or percentage of error is only an approximate average value of the effect of the various sources of error. When the result is the arithmetical average of several separate measurements of the same property, the accuracy is generally taken to be proportional to the square root of the number of such observations. The numerical average of the differences found by subtracting each measurement separately from the average of the measurements, divided by the square root of the number of measurements is known as the "deviation measure." For example, suppose four measurements be made of the thickness of a piece of glass, the readings being 0.412, 0.414, 0.411, and 0.413. The average of these is $1.650 \div 4 = 0.4125$. The differences between the separate measurements and the average are 0.0005, 0.0015, 0.0015, and 0.0005; these are called deviations, and the average deviation (algebraic sign is disregarded) is $0.0040 \div 4 = 0.001$. It may be shown by mathematics that the greatest probable error is not so great as this but is approximately equal to this divided by the square root of the number of observations. This would give for this case $0.001 \div 2 = 0.0005$, which is known as the "deviation measure." The probable value of the thickness is 0.4125 but is subject to an error not exceeding ± 0.0005. The result should therefore be expressed as 0.4125 ± 0.0005. Ex-

pressed as a percentage, the error is within $(5 \div 4125)\ 100 = 0.108+\%$, and the result might be expressed therefore as $0.4125 \pm 0.108\%$. However, the value of the error itself is subject to an error which in general is only within about 10%, so that it is usually not permissible to carry the value of the initial error beyond two figures. The proper expression, then, for this result is $0.4125 \pm 0.11\ \%$. When the accuracy of a quantity is said to be within (say) 1% it does not mean that the value given is necessarily in error by 1%, but that there is an uncertainty about it amounting approximately to 1% at most and that the true value may be anything between 1% more and 1% less than the stated value, although the stated value is the most probable value within $\pm$ 5 in the place next beyond the last one given.

In a general way the accuracy with which the value of a quantity is known may be indicated by the number of significant figures contained in the number expressing the value. A significant figure is any digit used to denote the value of a quantity in that particular place where it stands in the number. For example, the quantity 21.63 has a value of 2 in the tens place, 1 in the units place, 6 in the tenths place, 3 in the hundredths place, and has four significant figures. If this number is the probable value of some quantity it is understood that the figure 3 is the nearest value of the fourth significant figure; the actual figures in the fourth and fifth places may have been anything between 25 and 35. If the accuracy of this quantity is 1%, then the true value may be anything between $21.63 + 0.2163$ and $21.63 - 0.2163$, or between 21.8463 and 21.4137. This shows that the third and fourth significant figures are uncertain as to their true values; therefore we should not carry 1% of 21.63 farther out than the nearest second significant figure, namely 0.22. Furthermore, even if we were to call the error 0.2163, we have in the probable value no values for the fifth and sixth places and we are not justified in adding 0.0063 to unknown figures and calling the result 0.0063. The nearest we can get therefore to the value of the quantity is 21.63 ± 0.22. To show further that five places are not justified when the accuracy is within 1% but not better than 0.1%, the following examples of extreme cases are given. Take the number $10.142 \pm 1.0\%$. The value lies between 10.041 and 10.243.

Since the third figure is uncertain by an amount equal to its own value, the uselessness of the fifth can scarcely be questioned. Suppose the value is 10.142 ± 0.1%. It then lies between 10.132 and 10.152. In this case the fourth figure is in doubt by 50% of its probable value, so that again the uncertainty of the fifth is so great as to render it of very questionable usefulness. In following out this principle, it is to be observed that when the accuracy of a number is between 10% and 1% the fourth significant figure is always doubtful, and generally the third as well. When the accuracy is between 1% and 0.1% the fifth place is always uncertain, and generally the fourth also. And so on for other ranges of accuracy. Also since the percentage of accuracy itself is an approximation and may be in error by as much as 10%, another element of uncertainty is added to the values of the errors to be added or substracted. It would therefore seem to be well established that not more than three significant figures should be used for expressing the value of a quantity whose accuracy is between the limits 10% and 1%, not more than four for those between 1% and 0.1%, not more than five for those between 0.1% and 0.01%, and so on. When a number begins with 1 or 9 and the percentage of accuracy approaches the limits given, the probable accuracy is not much changed by using either the larger or smaller number of figures, but the above are the extreme numbers that are useful. It is very convenient to indicate the limits to the accuracy by the use of a proper number of figures, and it is very misleading to use an improper number.

It should be noted particularly that the position of the decimal point in a number indicates nothing whatever as to the accuracy of the number as representing the value of a quantity. Thus, a distance expressed as 0.1122 inches is indicated as having the same percentage of accuracy as the distance 112.2 inches, although it would, of course, require two different kinds of instruments to measure these distances. To assume that the voltage of a 110 volt circuit must be measured to 0.01 of a volt because the current flowing is 0.25 of an ampere, is an example of the absurdity of thinking that the number of figures to the right of the decimal point expresses the accuracy with which a quantity is measured.

Confusion sometimes arises in regard to the significance of the digit (0) zero. In the number 204.6 the zero is without question a significant figure. In the number 0.00126 none of the zeros are significant figures. In the number 2120 the zero may or may not be a significant figure; if the number is accurate within 10% only, the zero should be considered as not significant, while if the accuracy is 1%, it is a significant figure. Confusion can always be avoided by using the exponential 10 in connection with numbers having zeros immediately to the left of the decimal point. For example, 63000 $\pm$ 10% would be expressed as 63.0×10^3; 2,140,000 $\pm$ 1% would be 2140×10^3; 28, 630,000 $\pm$ 1% would be 28.63×10^6, and so on. Attention should also be given to the zeros following the decimal point. For example, if a distance of six feet is measured within 10%, it should be set down as 6.00; this would mean that while its actual value might be anything between 5.40 and 6.60, its most probable value is 6.00 $\pm$ 0.005. If it is within 1% it should be set down as 6.000. (In this connection it should be understood that whatever is set down as the most probable value of a quantity, there is always an error not exceeding $\pm$ 5 in the last place due to the rejection of figures beyond that place.) It is admitted that it is common practice to set such numbers down without the zeros following the decimal point; but by common consent they are understood to be there, although, unfortunately, there is then nothing to indicate how nearly accurate the number is supposed to be. If the voltage of a circuit is set down as 112., there is nothing to indicate that it is nearer to the truth than 10%, although in fact it may be accurate within 0.1%. In the absence of uniformity in this regard, judgment must be used as to the probable accuracy in such cases.

We may now consider the problem of how many places of figures should be used in making computations. The first principle which must serve as a guide in the matter is that the percentage of accuracy of a computed result cannot be better than that of the component factor whose own accuracy is poorest. (Herein lies the necessity of a uniform method of setting down data so that their accuracy may be correctly estimated. Attention is called particularly to the desirability of using the exponential 10 for expressing large numbers, and of setting

down the proper number of zeros after the decimal point in expressing small numbers larger than unity.) A result may be even less accurate than that of the factor of poorest accuracy if a factor of higher accuracy is raised to a power greater than unity; for if any factor is raised to the nth power, the initial error in it is multiplied something more than n times. For example, suppose the tensile strength of a test piece is measurable to an accuracy of 2%, while the diameter (d) is measurable to an accuracy of 1.5%; the area will be $\frac{\pi}{4}(d \pm 0.015d)^2$ or $\frac{\pi}{4}(d^2 \pm 0.03d^2 + 0.000225d^2)$, which shows a possible error of something more than 3%. Therefore the calculated tensile strength per square inch will be accurate only within about 3%. In general, if a quantity x is accurate within p%, it may be expressed as $x \pm \frac{px}{100}$; If this quantity be raised to the nth power, the resulting quantity is $x^n(1 \pm \frac{pn}{100} + \frac{p\,n(n-1)}{100(1.2)} \pm \ldots)$. Since p is usually small, the terms beyond the second in the parenthesis may be neglected, and the initial error may be considered as multiplied by the power to which the quantity is raised.

In consideration of all the conditions which have been discussed so far, it will be evident that careful thought and good judgment must be exercised in order to determine how far to carry out a given computation so that the result will be as accurate as the measurments warrant, and yet not involve a waste of time and energy in carrying useless figures.

The following may be stated as rules which presently will be shown to be justified:

> An accuracy within 10% will be secured in the result of any computation not involving more than 20 rejections, if three significant figures be retained in each factor, constant, product, quotient, power, root, sum, difference, or logariithm (not including the characteristic) used or obtained during the process of the computation.
>
> An accuracy within 1% will be secured under the

same conditions if four significant figures be retained throughout.

An accuracy within 0.1% will be secured with five significant figures; and so on.

Let the number of significant figures used be called n, and the number of rejections during the computation be called r. The problem is to determine the maximum possible error caused by r rejections and by using n significant figures only. A rejection means that at any one step in the process, such as multiplying two numbers together, all figures beyond the nth place are rejected, and the nth figure is increased by 1 if the (n+1)th figure is 5 or greater, but is left unchanged if the (n+1)th figure is less than 5. If three numbers are added together, rejections being made from each of them, it counts as three rejections. The maximum possible error caused by one rejection will be $\pm$ 5 in the (n+1)th place; and the maximum percentage error will occur when the first figure in the number is 1, the next (n—1) figures are zeros, and the (n+1)th figure is 5; in this worst case, the value of the error expressed as a fractional part of the number will be $5 \div 10^n$. (Very closely: if n=3, the error would be 5÷1005; if n=4, the error would be 5÷10005.) The maximum error caused by r rejections will occur when all the numbers are equal to the one just described, and when all the rejections are in the same direction; its value, expressed as a fractional part of the result, will be $5r \div 10^n$, since the error caused by one rejection will simply be multiplied r times. Expressed as a percentage, then, the maximum error that can be made by using n, and only n, significant figures through a computation involving r rejections, will be $500r \div 10^n$. Since this maximum error will be of exceedingly rare occurrence unless r be very small, we may with perfect security assume that the actual errors caused by rejection will give in the result an accuracy not appreciably less than that of the original data. This may be more fully appreciated after a little study of the following table which shows what these maximum percentages of error amount to for various numbers of rejections and for various numbers of significant figures used;

Table showing maximum percentages of errors for various numbers of rejections and numbers of significant figures used.

	n=3	n=4	n=5	n=6	n=7	n=8
r	%	%	%	%	%	%
2	1.0	0.1	0.01	0.001	0.0001	0.00001
4	2.0	0.2	0.02	0.002	0.0002	0.00002
5	2.5	0.25	0.025	0.0025	0.00025	0.000025
8	4.0	0.4	0.04	0.004	0.0004	0.00004
10	5.0	0.5	0.05	0.005	0.0005	0.00005
20	10.0	1.0	0.1	0.01	0.001	0.0001

In studying these figures, it must be remembered that they represent the maximum possible error and are based on the supposition that the numbers all begin with 1 followed by (n—1) zeros, that the rejected figures are all 5's, and that all rejections are in the same direction. The occasions when all the conditions anywhere nearly approach these suppositions are most extremely rare, and in general the actual errors are very much smaller than those given in the table. This is particularly true as the number of rejections increase, since the probability that the rejections cancel themselves will then increase. The number of rejections occurring in ordinary engineering work will rarely exceed ten, and will average more nearly five. Rules based on a maximum of twenty will therefore be perfectly safe. It will be remembered that four significant figures are all that are justified in expressing the value of a quantity whose accuracy is within 1%; it will now be seen that the maximum possible computation error with 20 rejections is only 1% with four significant figures and decreases in direct ratio with the number of rejections. The fact that the actual errors will be much less than these maxima, coupled with the additional conditions that there is always at least one uncertain figure attached to the values of the original data (if four figures are used for 1% accuracy, and so on) and that any stated

value of accuracy is in itself an approximation, gives assurance that the rules put down at the head of this paragraph are fully justified.

Further justification may be afforded by working out some problems illustrating the results that will be obtained by observing the above suggestions. In this way also some special points may be most easily emphasized.

Suppose the diameter of a tank is given as 16.0 feet; stated in this way, the accuracy with which it is known is only within 10%. In cases of this sort (that is, where the indicated error is larger than 1%) a definite statement of the accuracy ought to be made. Suppose, then, it is given as 16.0 ± 0.5. This would mean an accuracy within about 3%. What is the cross-sectional area? Since the diameter must be squared, the area will be accurate only within 6%. What value should be used for π in this case? 3.1416 is the correct value within one part in 300000. 3.142 is correct within 4 parts in 30000, or within 0.013%; 3.14 is correct within 0.05%; 3.1 is correct within 1.3%. By the rules, three figures should be used for an accuracy between 10% and 1%. $(3.14 \times 16^2) \div 4 = 200.96$, while $(3.1416 \times 16^2) \div 4$ gives 201.0624. The use of only three figures in the result gives 201 in either case, which is as large a number of significant figures as can possibly be justified. This example illustrates the uselessness of retaining (even in a constant of great accuracy) a number of figures which indicate an accuracy far beyond that of any other quantity which enters the computation.

Let it be required to figure the tensile strength of a piece of steel whose diameter is found to be 1.32 inches within 1%, and which breaks under a tension of 106×10^3 pounds within 2%. Obviously the accuracy of the result cannot be better than 2%. Placed in the shape of an equation, the tensile strength is

$$T = \frac{106 \times 10^3}{(\pi/4) \times 1.32 \times 1.32}$$

Using 3.1416 for π, performing the operation long hand, and rejecting no figures in the process, we get $T = 77458.16+$. Of course no one would think of using as many figures as this in stating the result, but they are set down here for purposes of comparison. If one had performed the operation as indicated,

he might give the most probable value as 77.46×10^3 which would be within 0.0024% of the value as calculated. By using $\pi = 3.142$ and rejecting all but four significant figures after each operation, values ranging from 77.42×10^3 to 77.49×10^3 will be obtained, depending on the order in which the steps are taken. The maximum deviation from 77458 is 0.049%. Any one of the values thus obtained should be accepted as a very close approximation to the most probable value, and, indeed, in the nature of the case, any one of them is as likely to be the true value as any other. By the rules given above, only three significant figures should be used for this computation. By using $\pi = 3.14$ and rejecting all but three significant figures after each operation, values ranging from 77.3×10^3 to 77.7×10^3 will be obtained, and the maximum deviation from 77458 is 0.31%. Since the probable value is correct only within 2%, the true value may be anything within $77.40 \times 10^3 \pm 1.56 \times 10^3$, or between 75.9×10^3 and 79.0×10^3. A value within 0.3% of the most probable value of a quantity subject to 2% error is certainly acceptable from an engineering point of view. Three place logarithms give 77.4×10^3, which is within 0.075% of the most probable value.

In addition and subtraction, the same general rules hold as for other operations. It may be noted, however, that when values are being added or subtracted they need not have the same number of significant figures. That number which has its first figure farthest to the left determines the number of places to be retained in the others. For example, find the value of $(21.21 \times 10^3) + 464. + 67.7 + 8.32 + 4.638$, within 1%. Setting these under each other and adding, we have

$$\begin{array}{r} 21210. \\ 464. \\ 67.7 \\ 8.32 \\ 4.638 \\ \hline 21754.658 \end{array}$$

To secure the required accuracy no figures need be carried be-

yond the fourth column from the left. The result is

$$\begin{array}{r} 21210 \\ 460 \\ 70 \\ 10 \\ \hline 21750 \end{array}$$

which is within 0.02% of the first result. Referring again to the accuracy as affected by the errors of measurement, it will be remembered that it was shown that with an accuracy of 1% only, a figure in the fifth place could have no definite value. Therefore, in finding the sum of the above quantities, the accuracy is not affected by rejecting entirely the value 4.638, although in principle it should be added with the rest.

For 0.1% accuracy, five columns of significant figures should be used, counting as the first column that one in which occurs the first significant figure farthest to the left; for 0.01%, six columns, and so on.

Let it be required to determine the number of ampere-turns required per pole for the magnetic circuit of a dynamo, made up as follows: 0.15 inch of air gap with a density of 56000 lines per square inch; 4.2 inches of pole piece with a density of 74000; 6.6 inches of field ring with a density of 38000; 3.6 inches of armature core with a density of 63000. From available data on the subject, it will be found that the pole will require 14 ampere-turns per inch at the density given; the ring, 8.8 ampere-turns per inch; the core, 7.5 ampere-turns per inch. The ampere-turns for the gap would be found by the formula, $AT = 0.3133\ Bl$. The item of greatest uncertainty in this problem is whether the materials actually used will require the same magneto-motive force as the test-pieces from which the data have been secured. This uncertainty may amount to 10%. The length of the air gap is also subject to an error which may amount to 0.01 inch or, say, 8%; and since the gap will require at least 90% of the ampere-turns, the influence of the variation in quality of iron is negligible. Three significant figures will insure freedom from errors of rejection, within 10%. It will be sufficient therefore to carry three places through the work. The gap will require $0.313 \times 0.15 \times 56000 = 2630$ ampere-

turns; the pole, $14 \times 4.2 = 50.4$; the ring, $8.8 \times 6.6 = 58.1$; the core, $7.5 \times 3.6 = 27.0$. The sum of these, by the rules given above, would be

$$\begin{array}{r} 2630. \\ 50. \\ 60. \\ 30. \\ \hline 2770. \end{array}$$

The elements of uncertainty in this problem would make it wise to use 2800 ampere-turns. This is a good illustration of the absurdity of using more figures than the conditions warrant. If all the figures are carried through, the result will be $2631.72 + 50.4 + 58.1 + 27. = 2767.22$ within 10%!

Let it be required to find the inductance of a 75 mile 2-wire transmission line of No. 6 B. and S. copper wires spaced 18 inches apart. A standard formula for this is

$$L = 0.08047 + 0.7411 \log \frac{D}{r} \text{ (Millihenries per mile)},$$

where r is the radius of the wire and D is the distance between centers of the wires. It should be obvious at once that the distance between wires is subject to a widely varying error, depending principally on the care with which the line is erected. Under the very best conditions, it is unlikely that a better accuracy than 10% can be assured. The radius of No. 6 wire is 0.081 ± 0.0005 inch. According to our rules three figures are all that are justified. $D \div r = 18 \div 0.081 = 222$; $\text{Log } 222. = 2.35$; $2.35 \times 0.741 = 1.74$; $1.74 + 0.08 = 1.82$; $1.82 \times 75 \times 2 = 273$. By rejecting no figures and using an 8-place logarithm for $D \div r$, the result is 272.9356. The difference between these results amounts to 0.024%. This illustrates the uselessness of carrying all the figures given in a formula, just because they are there, and also shows that even if an accuracy of 1% had obtained in the data and had been required in the result, it would have been secured with a large margin to spare in this case with only three figures carried. It serves to emphasize the fact that an accuracy far within 1% will generally be secured with four figures.

When the object of a computation is to obtain a result with-

in the limits of accuracy set by the data, the factor of poorest accuracy determines the number of significant figures to carry; but when the object is to obtain a result in which the rejection errors shall not exceed a specified percentage, the rules given herein should be used regardless of the accuracy of the data.

In a vast number of problems the accuracy of the data given is not known and in many cases is of no particular moment. All that is known or assumed is that the values given are the most probable ones within $\pm$ 5 in the last place of significant figures. Thus, 12. would represent a quantity whose probable value is between 11.5 and 12.5; 12.0, one between 11.95 and 12.05; 1200 one between 1195 and 1205; 12×10^2, one between 1150 and 1250. In problems of this sort, the accuracy of the result of a computation should be construed to mean the accuracy not as affected by that of the original data but as affected by the rejection of figures in the process of computation. If none are rejected, the result will be perfectly accurate under this construction of the term. The table given above shows what the maximum possible errors of computation will be under the different conditions given. However, in problems of this kind, judgment must be used so that an accuracy of computation shall not be demanded which is absurd, either on account of the fact that the result desired is only an approximate one which must afterward be adjusted to suit conditions, or because of perfectly well known inaccuracies in the data.

For example, let it be required to find the size of steam pipe needed for a 22″ by 28″ steam engine running at 138 r. p. m., assuming a steam velocity of 6000 feet per minute. The formula for this is

$$\mathrm{Dp} = \mathrm{Dc}\sqrt{\frac{\text{stroke} \times \text{r. p. m.}}{6 \times \text{steam velocity}}}$$

Substituting,

$$\mathrm{Dp} = 22\sqrt{\frac{22 \times 138}{6 \times 6000}} = 7.2116+ \text{ inches},$$

making no rejections. Evidently an 8″ pipe must be used. The result of using three places throughout is 7.26; of using two places and 140 r. p. m. instead of 138, is 7.3. In problems of this sort it is particularly absurd to carry more than three significant figures, and many times two are ample.

Let it be required to calculate within 1% the modulus of elasticity (E) of a wrought iron rod 0.812 inches in diameter, (d) when a load (P) of 11.20×10^3 pounds produces an elongation (e) of 0.004 in a length of 5.128 inches. The formula is

$$E = \frac{4Pl}{\pi d^2 e} = \frac{4 \times 11200 \times 5.128}{3.1416 \times 0.812 \times 0.812 \times 0.004}$$

Judgment will show at once that the accuracy of the result as affected by the measurements cannot approach as good a value as 1% since the elongation, 0.004 inch, cannot have any such accuracy as that. Nevertheless it may be desirable to keep the errors of rejection within 1%, and it is this phase of the problem that we are now discussing. By using $\pi = 3.1416$ and making no rejections (cancelling the 4's), we get the result 27,727,013.48+, which needs no comment as to its absurdity. By using $3.142 = \pi$ and four significant figures only, the result is 27.74×10^6, which differs from the first result by 0.048%, and is well within the 1% requirement. Also it may be noted that the error is less than 1/4 of the maximum possible error than can be caused by four rejections. (See table.) It happens that three significant figures will give a result within the requirements in this case. Using $3.14 = \pi$ and 5.13 instead of 5.128, and rejecting all but three figures throughout gives 27.7×10^6 which is within 0.26% of the first value found, and the error is only 1/8 of the maximum error possible with three figures.

Required the size of wire for the field coil of a dynamo which requires 3260 ampere-turns per pole, with 12 volts per coil and a mean length of turn of 27 inches. The formula is

$$\text{area in circular mils} = \frac{\text{mean length of turn} \times \text{amp.-turns per pole}}{\text{volts per coil}}$$

The mean length of turn can be estimated within 2%; the ampere-turns per pole within 10%; the volts per coil within 1%; but regardless of accuracy, the next larger commercial size of wire corresponding to the calculated area must be used. The difference between two consecutive sizes is 26% of the smaller size. Certainly, then, everything beyond the third figure should be rejected. $27 \times 3260 = 88.0 \times 10^3$; $88 \times 10^3 \div 12 = 7.33 \times 10^3$. No. 12 wire has 6530 circular mils; No. 11 has 8234. No. 11 must be used. Carrying all figures gives 7335 as the area required, which differs from the short calculation by 0.068%.

Required the size of shaft for 45 kw. armature running at 1400 r. p. m. A fair formula for this is

$$\text{Diameter} = 0.9 \sqrt[3]{\frac{\text{watts}}{\text{r. p. m.}}}$$

Carrying five figures, $45000 \div 1400 = 32.142$; $\sqrt[3]{32.142} = 3.1795$; $3.1795 \times 0.9 = 2.86155$. A 3-inch shaft is required. Carrying three figures only, $45000 \div 1400 = 32.1$; $\sqrt[3]{\overrightarrow{32.1}} = 3.18$; $3.18 \times 9 = 2.86$. Carrying two figures only $45000 \div 1400 = 32$; $\sqrt[3]{32} = 3.2$; $3.2 \times 9 = 2.88$, which differs from the five-figure result by less than 2 parts in 3000 or 0.064%.

Required the weight in pounds per cubic inch of a short cylinder of brass which is 0.4263 inch long, 0.2178 inch in diameter, and weighs 61.62 grams.

$$W = \frac{61.62 \times 0.002204622}{0.7854 \times 0.2178 \times 0.2178 \times 0.4263}$$

Regardless of the accuracy of the measurements, let it be required that the result shall be free from rejection errors within 0.25%. There will be five rejections in the computation. By the table on page 263four significant figures only cannot cause an error exceeding 0.25% in five rejections. Using 0.002205 as the number of pounds in a gram and rejecting all beyond four figures in the process, we get 8.553. Making no rejections we obtain 8.55477+, which shows an error due to rejections within 0.021%. If one works this problem long hand making no rejections, or, with 8-place logarithms, then repeats the work long hand rejecting all but four figures, or, with 4-place logarithms, the great amount of labor and time used to gain an accuracy of 0.021% will be appreciated. Although it would not always be safe, the use of three figures in this problem gives 8.550 as a result, which is within 0.055% of correct.

In the application of the rules suggested in this paper to problems which are given for the purpose of illustrating theory as well as practice, there may be cases where an instructor will be in doubt as to whether the student really understands the principles; but if it be required that full explanation be given in regard to any rejections which do not explain themselves,

there is no doubt that much valuable time can be saved to be put upon a study of the principles.

Examples might be added indefinitely to show that from the viewpoint of accuracy as well as of time and labor saving, the rules which have been given are justified and worth careful attention. Much is said about "engineering accuracy". If we can bring ourselves to realize the difference between accuracy and absurdity and learn how to secure reasonable accuracy without carrying the burden of useless figures, we shall find much more time for things which are useful.

Single Phase R. I. Motors

F. D. Paine, E. E., '09.*

It is not the intention of the writer to go deeply into the theory of the single phase repulsion induction motor which is built by the General Electric Company, but merely to give the simple theory of its development, the essential details of mechanical construction, and the characteristic points in its operation.

By placing an ordinary direct current armature in a laminated bi-polar field, as shown in Figure 1, and short circuiting the brushes we have the simple repulsion motor. If the brushes are first considered as in the dotted position, it may readily be seen that the coils in the armature are in the same relative position with respect to the coils of the field as the secondary of a transformer is with respect to its primary. With the armature short circuited through the brushes and with current flowing in the field winding, it is evident that the armature acts as a short circuited secondary on a transformer. There will be a large current flowing with very low voltage. With the brushes in the dotted position, however, the field flux is opposed by the armature flux, the resultant flux is zero, and although the armature turns carry current there is no torque action. If the brushes are shifted through an angle "A" as

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shown in the diagram, a resultant flux will be produced which acting upon the armature conductors carrying current, will in turn produce a torque action. It may also be seen that we have, on account of the shift in brush position, a generated electromotive force, and consequently the armature will run at a speed sufficiently above synchronous speed to make the counter E. M. F. equal to this generated E. M. F. If another set of brushes are placed on the commutator 90 electrical degrees from the first, the motor will come up to and run at synchronous speed.

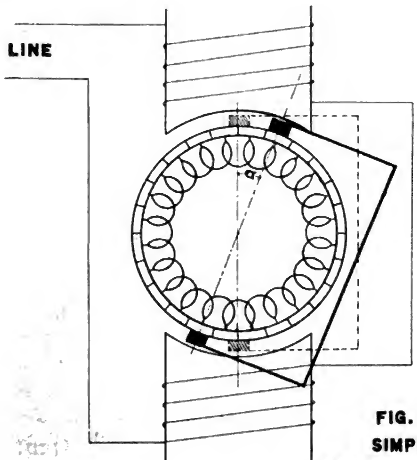

FIG. 1
SIMPLE
REPULSION MOTOR

Although in the above case we would have a single phase motor, its running characteristics, especially the power factor, would be too poor to warrant the construction. If instead of short circuiting the last set of brushes, we connect them to a source of low e. m. f. in phase with the main field, such as an e. m. f. generated by the concentric field shown in Figure 2, we can raise the power factor.

Referring again to the e. m. f. in the short circuited or energy winding, it is evident from the theory of transformers

that the e. m. f. here generated is in time quadrature with the flux. On the other hand, the e. m. f. of the concentric field or the compensating e. m. f., is in phase with the flux and the two electromotive forces are in time quadrature with each other. Consequently, by impressing this e. m. f. on the compensating circuit, the current which flows will lead the load current by an amount sufficient to compensate for the lagging exciting current of the machine. The fact that the compensating current through the armature is necessarily 90 degrees in advance of the load current, accomplishes the compensation for power

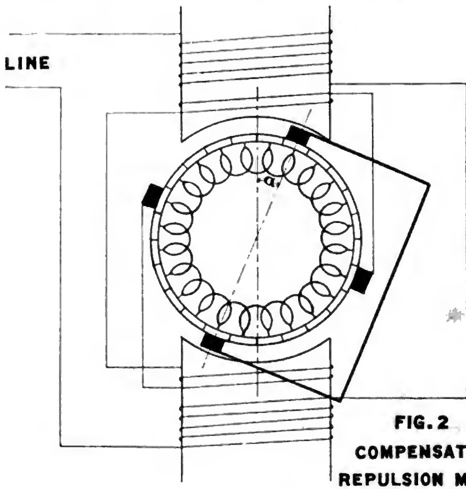

FIG. 2
COMPENSATED
REPULSION MOTOR

factor with the smallest possible volt-ampere value and consequently with the smallest power consumption. The result of such compensation with the correct e. m. f. impressed on the brushes is to give approximately unity power factor at full load and high power factors at other loads.

In the R. I. motors as they are built by the General Electric Company, this compensating circuit consists either of field coils concentric with the main field or of taps taken from the main field at points which will give the proper voltage. Inci-

dentally to the impressing of the compensating e. m. f., the armature will be driven at a speed sufficiently above synchronism so that the voltage generated will equal the voltage impressed. If the compensating circuit should be connected incorrectly, the result would be a power factor considerably below that of an ordinary induction motor.

Considering the different electromotive forces, and the different currents which each set of brushes carry, the characteristic sparking conditions for this type of motor may be specified. The coils of the armature terminating at the compensating brushes are in a position to have an e. m. f. induced in them,

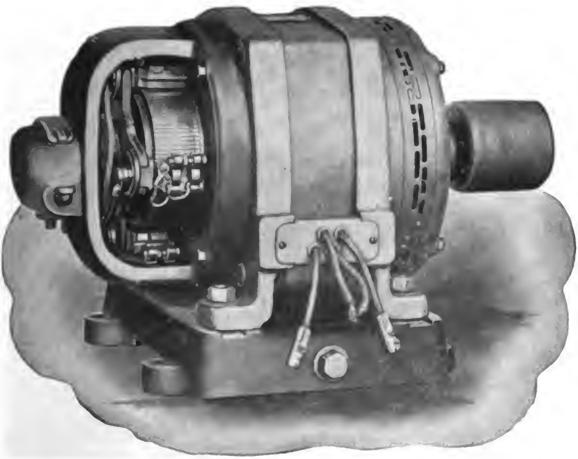

Fig. 3. Assembled Repulsion Induction Motor

but due to the general short circuit by the energy brushes, the tendency of this induced e. m. f. to produce sparking is slight. The armature coils of the energy circuit are not in an inductive position but the generated e. m. f. has a tendency to produce sparking. On account of the rotating field this e. m. f. is zero at synchronous speed and since the current which the compensating brushes carry is small, better commutation results.

The general mechanical arrangement of the active material resembles in many respects that in a direct current motor. Referring to Fig. 3, the commutator, brushes, and brush rigging are seen to be almost identical with corresponding parts on a direct current motor. Although the motor is a single phase alternating current machine, the brushes stay on the commutator at all speeds and loads.

The motor is built in sizes ranging from ¼ to 15 H. P. The riveted frame design is considered standard for motors up to 7½ H. P.; above this capacity the skeleton type of frame is used.

The riveted frame consists of many laminations riveted to-

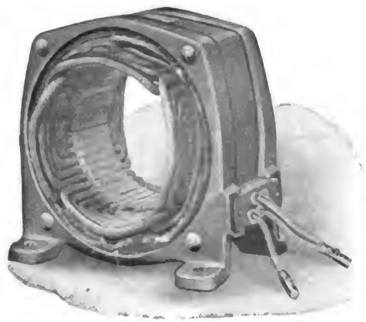

Fig. 4. Wound Field of type RI 3 H. P. Riveted Frame Motor

gether between two end shields, which are so cast as to form the lugs for bolting the frame to the base. This feature of the construction can be seen in the foreground of Fig. 3. The laminations being one punching form the slotted field cores as well as the external surface of the machine. With this construction, both the outer and inner surfaces are exposed to the air. In this way not only are compactness and rigidness secured, but very effective radiation as well.

The main field winding consists of concentric wound coils of the distributed type. The coils are form wound. The distribution of the winding for the proper pole arrangement is

clearly shown in Figure 4. The second field winding or compensating winding cannot be seen in the figure but it is either a separate winding wound concentric with the main field or is obtained by tapping the main field winding at points to give the proper voltage.

Figure 5 shows the armature of the motor and makes apparent its close resemblance to that of a direct current motor. For purely mechanical reasons the series drum type of armature is employed. The core is laminated, and because of its being used in an alternating current motor the slots are overhung. The commutator, as can be seen, is similar to a direct current commutator. These commutators are slotted to give a low contact resistance and better commutation. The armature circuits being of low voltage, but of high current density, a slight increase in brush resistance seriously affects the general operating characteristics and gives rise to induced voltages

Fig. 5. Complete Armature type RI 3 H. P. riveted frame motor

which may cause serious sparking. The trouble arising from short circuiting commutator bars is slight since the voltages are so low.

The air gap in this motor corresponds to regular induction motor practice rather than to direct current practice. To increase the ventilation and hence the capacity of the machine for a given radiating surface, a fan is rigidly mounted on the shaft at the pulley end, as shown in Fig. 3.

Considering the starting and running characteristics, we find that the starting torque developed on closing the main line switch is 250 per cent of that when running. The starting current, corresponding to full load is from 2 to 2¼ times full load current. This current is only momentary and drops very

rapidly as the motor accelerates in speed. Motors of normal voltage and frequency attain rated speed under full load in from 2 to 5 seconds. For these reasons and because of the high power factor, the voltage regulation on a lighting circuit to which the motor may be attached is only slightly affected and then only for a negligible period. Starting rheostats are not required except on the 7.5, 10, and 15 H. P. motors.

The efficiency curve shown in Fig. 6 furnishes the following

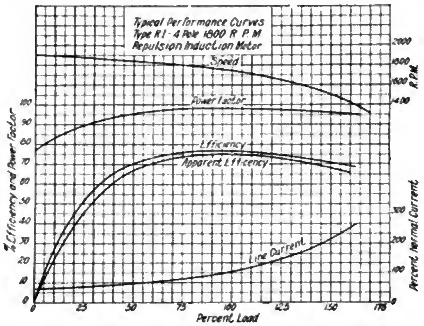

Fig. 6. Performance Curves of R. I. Motor

information. From full load down to 75 per cent full load the motor develops an efficiency of about 77 per cent. The power factor curve shows that the power factor during the same range is about .98. This is remarkably good for an induction motor The speed regulation calculated from the curve is about 8 per cent.

It might be mentioned further that these motors are also built in reversible and variable speed types.

Is a County Engineer Necessary?

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In discussing the advisability of creating the office of County Highway Engineer let us first consider the magnitude of the road and bridge problem in this state. According to statistics compiled by the office of Public Roads in 1909, there are in this state over 102,000 miles of public highways. This mileage is exceeded by only two states in the union,—Missouri and Texas.

As a basis of comparison, let us consider the mileage of some of our largest railway systems. The Chicago & Northwestern Railway has 9,700 miles of track, and the Chicago, Milwaukee & St. Paul Railway has 8,900 miles of track, or either of these great systems has less than one-tenth of the mileage that Iowa has in her public highways. Going a little farther, we find that the ten largest railway systems in the United States have a combined mileage of 103,000 or an amount approximately equal to the miles of public roads in this state.

Of the highways in Iowa perhaps not more than fifteen per cent or about 15,300 miles are what might be called "main traveled" roads. In improving our highways these main traveled roads will necessarily be the first to be given consideration. When we consider the amount of money to be spent upon this primary system of highways in order to properly provide for the present and anticipated future traffic, we are astounded at the enormity of the undertaking. In improving these roads so that they will be in reasonably good condition every day in the year, the drainage must be perfected, the hills must be cut down, fills made, and after this is accomplished, some form of surfacing must be put on the roadway thus provided. The cheapest and in many counties the most available material for surfacing the roads is gravel. In the average county in the state the cost of grading, draining, and graveling the roads will amount to about $2,500 per mile. The cost of improving

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the 15,300 miles of such roads will be about $38,250,000 or an average of $386,500 per county. This includes only the "main traveled" roads, and does not take account of the amounts which the townships will spend on the township road systems.

No accurate statistics are available regarding the number of the bridges in this state. Adair county in the southwest part of the state has 4,200 bridges of which over 2,000 are twenty foot span or above. The majority of these 4,200 bridges are of more or less temporary nature and will require attention soon. Polk county has 930 bridges with an average span of 34 feet. Seven hundred and fifty of these bridges are at the present time either wood or steel, and are in very bad condition. This county has spent over $300,000 in the construction of 265 concrete structures which have an average span of 10.5 feet.

From the statistics available it appears that the average county has approximately 1,600 bridges. The average cost of replacing these structures with permanent work as shown above will be about $1,000 per bridge, or the total cost for building all the bridges of permanent construction will amount to $1,600,000 per county, or for the ninety-nine counties in the state the cost of permanent bridges will be about $158,400,000.

The state has expended in the past year, approximately $7,500,000 on roads and bridges; an average of $76,000 for each county. The proportionate expenditure for roads or for bridges cannot be accurately determined, but the bridge fund for the majority of the counties is close to $30,000 per year. In addition to that, the townships spend a large amount of their road fund on culvert work so that the funds as now spent are about equally divided between roads and bridges.

Any railway operating on sound business principles would have an efficient organization to superintendent the expenditure of any considerable amount of money. They would demand complete plans and specifications and records which would show itemized statements concerning every dollar spent. No money would be paid out of the treasury until it could be shown to the board of directors that it was a legitimate expense. To secure these results they would employ an efficient engineering organization to make the surveys, establish the grades, write specifications, draw the plans, superintendent

construction and keep the construction records clear and straight.

Let us compare such an organization with the one in vogue in many of the counties of the state. It is a fact that the majority of the money spent on road work last year was expended without a plan or profile on file to show where or how the money was to be used.

Last season, one county confined the attention of their elevating grader crew to a short strip of road possibly three miles in length. This work was in a hilly country where much cutting and filling was necessary, yet no survey was ever made of the road. When the work was completed, the superintendent was unable to tell the total yardage of material moved, or what the cost for moving the material had been per cubic yard. Had plans been prepared for this work and accurate cost data kept it would have been particularly valuable to the county in estimating future work under similar conditions. Most of the grading work has been done in such manner as to provide insufficient surface drainage. Roads are graded and well crowned yet the side ditch drainage has been incomplete. The water is allowed to collect in low places in the ditches and stand there until it evaporates or soaks into the roadway.

An example of absolute waste of money came to our attention recently. The board of supervisors together with a number of interested taxpayers attempted to construct a gravel road approximately nine miles in length. This road was located on low land with little surface drainage. Gravel was hauled upon this road and dumped so as to give a depth of ten inches. No provision was made for either sub-surface or surface drainage. The road was not even crowned before the gravel was placed. Such violation of engineering principles are costly experiments to the taxpayers, and show gross neglect or incompetence on the part of the supervising official.

The loss of money has not been confined to roads alone; investigations show that a very great loss has occurred in the bridge fund. Much of this loss is directly due to the yearly contract system which has been in vogue in many of the counties of the state. Under this system bridge contracts are let in blanket form. They call for no specific number of bridges and no specific location for any bridges bid upon, and as a result,

the general design and the location of the structure in the field is left to the supervisor and bridge company's foreman. When such a contract is let, it is impossible to have detailed plans for the various bridges. Where any plans at all are submitted with the bids, such plans are incomplete, and will not fit the varying conditions of the different locations. Consequently when any bridge is built, there is item after item of extra charge for work not called for in the contract. Such charges, for work not covered by the contract often run the price of the completed work up to a figure far in excess of what the work is worth, or what it might appear from the contract that the total price would be.

As an example of this, the following bill rendered by a bridge company for repairing an old 60 feet steel span is a good illustration.

To building 2 concrete abutments 12′ deep and encasing old piers:

Building 1 (10′6″) wing, one 11′6″, one 25′9″ and one 11′6″ wing	$2,935.00
Driving 11 steel piles at $7.00 each	77.00
Lowering old bridge 4′ and cutting off old cylinders	160.00
Filling north and south sides, including removal of old approaches	184.00
Laying floor and hauling lumber and freight on same to Follett's	36.00
Steel joists for 60′ span at $5.50 per ft.	330.00
Lattice railing on span	96.00
Angle to reinforce floor beams for holding joists and drilling floor beams	74.00
	$3,882.00

This bridge after being repaired was yet an old, flimsy, steel bridge with wooden floor, and will have to be replaced in a few years. Under the same contract the county could have built a new 60 foot riveted steel bridge with concrete floor for $3,830.00 or an amount of $52.00 less than the price paid and this price ($3,830.00) could have been reduced several hundred dollars if a competent engineer had been employed by

the county, before letting the contract, to plan and superintend the work.

These specific examples are only a few of the many which occur each year under the present system. It is the direct result of the hit and miss methods of road construction that are costing the counties thousands of dollars annually. We are trying to build roads with only a part of an organization. We have the "Board of Directors," but have no adequate engineering organization.

Bridges must not be built too small to provide sufficient waterway for passing the run off from the watershed above

Fig. 1. The result of too small a waterway

them, and in the interest of economy neither should they be made too large.

An example of the result of providing a waterway too small, is shown by Figure No. 1. This structure was a 50 foot arch bridge built in 1910. The cost to the county was about $3,000.00. Two years later, or in 1912, the structure collapsed during a freshet, and after the water had gone down it was found that the current had widened the channel by cutting behind the west abutment. As this was a patented type bridge which used the earth pressure behind the abutments to help support the arch, and which has shallow founda-

tions as one of its characteristic features, the result of washing out the fill was the collapse of the structure.

As an example of building bridges too large for the demands of the drainage area, the bridge shown in Fig. 2 is a good illustration. Here a forty foot riveted steel span with concrete floor and concrete abutments eighteen feet high was placed over a stream having a total drainage area of sixty-nine acres. This bridge cost the county $5,187.00, when the run

Fig. 2. This 40 ft. steel span on 20 ft. abutments has a drainage area of only 69 acres. Cost $5,187.00

off from the watershed could have been carried by a 4′x4′ box culvert costing about $500.00. The county in which the bridge is located has an approximate area of 440,000 acres, and at the rate shown above it would cost $32,700,000, to bridge the entire county. The bridge fund in this county is about $30,000 per year, or at the above rate it would require the entire bridge fund for 1,100 years to get once over the county with so-called permanent bridges.

Under the systems usually used in the counties, the general design and the location of the structures are left to the supervisors and to the bridge company's foreman. The majority of supervisors are not trained bridge men, and the bridge company's foreman is not working for the county. As a result there are many examples of improper locations and designs. Bridges are often located several feet above the proper position. In a number of cases, we have found concrete bridges located high upon the bank at one side of the stream, and with the pavement or floor six or ten feet above the stream bed. In other cases bridges are so located as to require excessive

Fig. 3 A good example of improper location and excessive length of wing wall

length of wing walls. In one case, a forty foot span steel bridge with concrete abutments and three wing walls cost $2,925.00. This bridge was so located that the other wing wall was made 60 feet long, and the price paid for this wing was $2,262.00 or an amount nearly as great as the cost of the remainder of the bridge. Another bridge in the same county has one wing wall 80 feet long. This wing extended out into the field, and does not hold up any fill or serve any other purpose which would justify the expenditure of so much money.

In most cases, no estimates are prepared showing the labor

and material required to build a given piece of work and when the work is completed the bill presented is allowed by the board without question. This is well illustrated by the record in one county where bills amounting to $57,000.00 and covering a whole year's work were allowed by the board at one session which lasted not more than three hours. Apparently none of these bills were checked against the structures built as evidenced by the following:

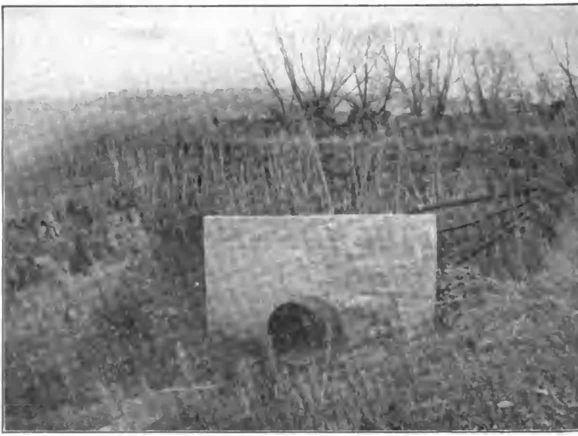

Fig. 4. The concrete in this Culvert cost $50.00 per cu. yd.

One of the bills contained the item—

"Building concrete abutments and 2 wings....$737.10"

Investigation disclosed the fact that only one abutment had been built, and that it contained only 15.91 cubic yards of concrete or the price paid was $46.33 per cubic yard. Another bill for construction on the bridge shown in Fig. 4, contained the item,

"One-half contract price for building concrete
crete bulkheads 16'x20' long on 48" steel culvert
36' long ....$390.00"

This bridge is located on the line between two counties and

hence the bill was presumably approved by two boards of supervisors. The bill apparently included only the building of the concrete bulkheads.

Investigation showed that the two bulkheads contained only 15.45 cubic yards of concrete or the price paid was at the rate of $50.48 per cubic yard. According to the engineer who made these investigations, a fair cost for the concrete in each of these jobs would be $12.50 per cubic yard. Another example of the loose system under which the bridge business is handled in many counties, is shown by the following invoice:

To one 14′ span with 12′ foundations	$ 720.00
Less acct. abutments 8′ deep 8′ at $9.00	72.00
	$ 648.00
Lattice railing	$ 28.00
One 16′ wing, one 10′ and 2-8′ wings	382.00
	$1,058.00

When this bridge was examined it was found that the charge of $28.00 for lattice railing was a double charge as the railing had already been paid for in the charge of $720.00 for the first item. A photograph of the bridge referred to is given in Fig. 5.

Quite often, bridges are built which provide roadways entirely out of proportion to the requirements of present or anticipated future traffic. This was well illustrated in one county where a bridge was found with a 40′ roadway. The location was such that an addition of filling over the culvert at some future date was impractical. The fact that the bridge was upon a road seldom frequented, made this width of roadway very excessive. Not a mile from this bridge, on an adjajent road with a great deal more traffic was another bridge with an available roadway of less than twelve feet. Had a study been made of present and future traffic conditions on these structures, they would never have been built as we found them.

Frequently, it is possible to relocate a road and thus avoid building one or more bridges. The following is given as a typical example. In one of the counties, a new road about three-quarters of a mile long was established in such a location that two forty foot bridges costing over $2,000.00 each were

required, when by a slight relocation of this road, such as any engineer would make, both of these bridges could have been avoided at a saving of nearly $4,000 and a better road secured.

In some of the counties we have found conditions for which the county boards alone are responsible yet in the majority of cases the state is a partner with the county boards in the mismanagement of our highway funds, owing to the fact that inadequate laws and an insufficient organization have been provided for handling the work. Road building is a business and

Fig. 5. The lattice railing on this bridge was paid for twice

not a side issue to the management of a large farm, or extensive business enterprise. It is hardly fair to a farmer or business man to elect him to the office of county supervisor where he has the spending of thousands of dollars annually in a kind of work with which he is not familiar, and then not provide him with the assistance of men trained in that particular line.

Before we can expect to secure the best results from the money spent on our public roads, we must provide an efficient engineering organization to work with our board of supervisors.

We must give our county supervisors the assistance of the technical training and years' of experience which go to make a finished road engineer.

The Legislature recognized this fact when in 1904 it passed the bill creating the present State Highway Commission. The appropriation for carrying on the work was, however, pitiably small, and although increases in the appropriation have been made from time to time, yet the demands for assistance from the Commission have increased at a much faster rate than have the appropriations, and the Commission is at present unable to carry on the work properly on account of a lack of funds.

Fig. 6. Not the result of a flood but lack of proper pile driving

One of the most difficult parts of the work of the Commission has been to get the bridge and road work constructed in the field exactly as shown on the plans. In the majority of cases the work has been constructed without any adequate inspection or engineering supervision in the field. At times, carefully prepared plans have been practically ignored, and in one instance a very inferior arch bridge was built from carefully prepared plans for a flat top bridge.

To properly handle the work and prevent such miscarriage of plans as shown above, each county should employ a highway engineer whose duties would be:

To survey the roads and prepare profiles and estimates giving proper attention to drainage, traffic, surfacing, etc.

To relocate roads so as to avoid expensive bridges and excessive cuts and fills.

To prepare detailed plans, specifications and estimates for each bridge built.

To survey the drainage areas and plan the bridges with due consideration to the waterway required.

To inspect the work frequently and see that it is done according to the plans and specifications.

To keep a complete and accurate record of the amount and locations of the work done.

Such an engineer working in connection with the State Highway Commission would complete the organization and would render invaluable service to the cause of "good roads."

THE IOWA ENGINEER

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EDITORIAL

The article by Professor Fish, "The Accuracy of Engineering Computations," which appears elsewhere in this issue of The Iowa Engineer, is one which should be met with considerable interest by students of engineering generally. Many of the points brought out therein have direct bearing on the general subject of accuracy in engineering practice. One of the most perplexing questions, especially to young engineers,

and one which even experienced engineers by no means altogether escape, is to be able to judge to what extent accurate mathematical and other scientific methods shall be allowed to govern the final results that are to be adopted in practical work. The young engineer, just entering his professional career, will find that one of his first practical problems will be, not the unlearning of what he has acquired from his college course, but the adaptation of that knowledge to the ever new and complicating problems of every day actual practice. An imperative necessity exists and always will exist for both the accuracy of scientific methods in engineering practice and good judgment based upon sound educational training and experience in dealing with actual engineering problems. As a rule, engineering computations should be accurately made with the understanding that the precise degree of accuracy which is to be attained must be tempered by the exercise of good judgment gained by experience with the conditions of each case. Engineering computations are not in the same category with those required in purely scientific work and it is a waste of valuable time to attempt elaborate computations when shorter and simpler methods of procedure will adequately meet the requirements of the case.

Of all questions which have been discussed in the present legislature, none has received more consideration than that of good roads. The economic need of a system of highways is recognized on every hand, but the proposition of providing a workable method for building these highways is not so easily understood. The article in this issue cites examples showing where much money has been needlessly wasted in bridge construction over the state. The natural tendency has been to blame the county boards administering these funds for any unwise or wasteful expenditures. This has been done in many cases by newspapers who champion the good roads movement. It would seem to be manifestly unfair to thus question the intentions and integrity of county officials, when the difficulty is largely due to the system under which the expenditures have been made. The average member of a county board has very little knowledge of the engineering details of bridge or road

construction. No matter how anxious he might be to honestly audit a bill for such charges, he would find himself hopelessly at odds with the competent engineers of contracting companies. The natural solution that presents itself is to furnish the county board with a representative skilled in engineering, who can be depended upon to work for the interests of the county. This is the nucleus of the argument in favor of a county engineer for each county.

The article gives something of an idea of the enormous amounts of money which must be spent during the next few years on roads and bridges. An individual or corporate organization would consider it folly to expend such sums without engaging the services of best engineering talent. There is no valid reason why the same care should not be exercised in the use of public funds. The success which has attended the work of county engineers in counties where they have been engaged is ample justification for their employment. In all cases, the amount saved the county has far exceeded the salaries and other costs of maintaining the office. The county boards have found him a valuable advisor, and the people are assured that bridge and road funds are being spent judiciously and wisely.

COLLEGE NOTES

The names of the honor students for the class of 1913 have been given out by the Registrar of the college. The list in order of standing is given below:

E. S. Wells, Science.
Paul Clapp, Electrical Engineering.
A. W. Hess, Mining Engineering.
Paul Kreithe, Animal Husbandry.
R. B. Reis, Mechanical Engineering.
Roy G. Ross, Veterinary.
Chas. Dorchester, Agronomy.
Lyle F. Watts, Horticulture and Forestry.
Blanche Hopkins, Home Economics.
Earl Bisbee, Dairy.
Hans Pfund, Ceramics.
Herbert Miller, Civil Engineering.

Tau Beta Pi, honorary engineering fraternity, have elected nine Juniors to membership. To be elegible for election in his Junior year a man must stand in the upper one-eighth of his class in scholarship. A further requirement is that the candidate show worthiness in the general activities of the college and that he be broad in his dealings with fellowmen.

The men honored by election are as follows:

Roscoe Shaeffer, Electrical Engineering.
L. E. Hulse, Electrical Engineering.
E. G. Nichols, Electrical Engineering.
Gates Harpel, Electrical Engineering.
D. S. Barry, Mechanical Engineering.
R. A. Schreiber, Mechanical Engineering.
H. J. Renken, Mechanical Engineering.
H. E. Freund, Mechanical Engineering.
L. S. Packman, Civil Engineering.

As matters now stand, the school question is still far from settlement. The Klay substitute, which was almost unanimously passed by the House, provides that all three schools shall remain as they are at present; a vote of seven members of the Board, however, will be sufficient for a change. Since it will be necessary for the Governor to either reappoint or name four new members of the Board before the legislature adjourns, the responsibility shifts from the legislature to the Governor. All indications are that the senate will not act favorably on the Klay substitute. In this case the Board will be vindicated and the proposed changes will be carried out. The Senate committee are expected to make their report some time in the week March 17 to 22.

The Deans of the College in a recent meeting voted to recommend to the State Board of Education that the following changes be made:

College work to commence the third Monday in September.

Christmas vacation to be shortened to three weeks, ending on Monday instead of Saturday.

The length of semesters to be equalized making each semester eighteen weeks long. This will make the semester examinations come after the Christmas vacation.

ALUMNI NOTES

Lee Taylor, Min. E., '12, has changed his location from Anaconda to Hayden, Arizona. He is working for the Ray Consolidated Copper Co.

E. C. Cutler, M. E., '12, is now in the drafting room of the Alamo Gas Engine and Supply Co., with an excellent chance of promotion. His present address is 2005 St. Mary's Ave., Omaha, Neb.

F. H. Klippel, E. E., '11, has accepted a position with the Nevada-California Power Co., at Goldfield, Nevada. He was formerly chief inspector for the Public Service Electric Co., Chicago Heights, Ill.

H. T. Borsheim, M. E., '04, is designer for the Hart-Parr Co. of Charles City, Iowa.

C. E. Olson, C. E., '12, has just completed a $20,000 concrete bridge in Greene Co., Iowa.

B. L. Taylor, C. E., '12, is county engineer of Woodbury Co., Iowa. He recently received plans from the Highway Commission for 18 concrete and steel bridges to be built in his county next summer.

Earl D. Andrews, who finished his school work in 1909 and received his diploma in 1912, graduated at the School of Mines in Golden, Colorado, last June.

Glen LaSourd, M. E., '12, is now employed by the Iowa-Nebraska Public Service Co. at Missouri Valley, Iowa. This company supplies light and power to Missouri Valley, Logan, Jonesville, and Magnolia, Iowa, and to Blair, Nebraska.

E. Z. Weldon, C. E., '12, is now chief engineer of the Columbia and Northwestern Ry., Golden, B. C.

James Greer, Min. E., '11, is foreman of an architectural business owned by his brother in Kansas City.

J. S. Clarkson, Min. E., '12, is situated in a mining camp at Gillespie, Ill.

Star Thayer, E. E., '08, is managing the electric light plant at Rock Valley, Iowa.

Delbert Wheeler, C. E., '08, is operating a telephone exchange at Ireton, Iowa.

CONTENTS

Passenger Station, C. & N. W. Chicago, Ill. This Building with the terminal was erected at the cost of $20,000,000 W. C. Armstrong B.C.E. '81 Eng.-in-Charge

THE IOWA ENGINEER

VOL. XIII. MAY, 1913 NO. 8.

Public Utilities Valuation

George W. Hand*

Part Two

It is a well known fact that the sequence in which various steps in the process of building a railroad follow each other greatly influences the cost of various items. The first thing that the valuation engineer needs to determine is the sequence possible under existing conditions that will result in the least cost of construction of the entire property. Then the unit costs applied must have been derived from or represent the cost of work done in the same sequence insofar as that element may effect them. The sequence that must be observed in any particular case will be prescribed by the local conditions involved in the work and the relative magnitude of each part of it. As illustrating some of these things take masonry culverts. It is generally cheaper to build temporary timber bridges where culverts are required and construct the masonry work after the track has been built so that the masonry materials may be hauled directly to the site of the culvert on cars and thus avoid transporting it overland by teams, a very expensive process. On the other hand, some situation may exist that would make the cost of the timber for the temporary structure exceed the cost of hauling the material for the masonry structure, for instance, stone might be procured near at hand so that the team haul would be short, whereas, if timber was first used it might have to be hauled from a point so far distant that the transportation of timber would offset the saving otherwise effected. In another case, it may happen that the bridge work is so extensive that to first build timber structures and then con-

*Valuation Engineer, Chicago and North Western Railway Co.

way and station grounds, yards and terminals in itself presents a special problem. In estimating the cost of reproduction the problem is of course to determine the cost of acquiring such an area at the present time assuming that heretofore it has not been occupied by a railroad, but has been devoted to such other purposes as it would be assumed to be used for judging from the purpose for which adjacent lands are utilized. It might be significant to mention that such an assumption is purely imaginative in many cases as many pieces of land adjacent are devoted to purposes that could under no possibility be used for such purposes if the railroad were not there to afford transportation facilities. Such an assumption is justifiable, however, on the ground that under normal conditions it will probably not lead to results far out of the way. Something tangible must be assumed. To open the door to speculation as to what might be the condition would lead to all sorts of difficulties. It might, for instance, be assumed that the right of way would be filled up with costly mansions, large public buildings, stores, factories, etc., and that in estimating the cost of acquiring it, allowance should be made for such conditions. Such assumptions could not prevail.

The cost of acquiring land for railroad purposes consists of two elements: First, the market value of the land for the use to which it is being devoted; second, the damage that may be occasioned to the residue where only a portion is taken for the right of way. This damage results from various conditions that arise from the construction of a railroad across a piece of property. In locating a line of railroad the most important consideration is to locate it where it will be least expensive to construct and operate. This necessitates crossing lands in almost any direction, following countours, etc., without regard to the effect it may have upon the lands crossed.

In country districts the construction of the line results in damaging farms by reason of the inconvenience to the owner in having his fields cut up and part of his farm on one side and part on the other side of the line. If the line runs straight east and west or north and south the damage to farms would be less than if it runs in an irregular course for although farms will be cut up still the fields remain rectangular in shape, a condition better adapted to cultivation than if they are of irregu-

lar shape as would be the case in the latter example. It sometimes happens that a railroad separates a small portion of a farm on which the buildings are located from the remainder of the farm, sometimes the line may run between the house and barn or through an orchard. Sometimes it may happen that in addition to cutting off a portion of a farm which would be an element of damage in any event a deep cut or high embankment may be located in such a way that it is inconvenient to have a crossing situated at a point that would afford the most direct access to the severed portion of the farm and thus the damage is increased. In addition to these and other similar elements of damage the noise and smoke of trains and engines, the danger of fire, etc., are recognized as elements of damage.

In towns and cities other elements exist. The right to secure abutting damage occasioned to property nearby but not actually a part of the land taken by the railway is recognized. There is usually some inconvenience occasioned to property owners adjacent to a railroad because of the fact that the proximity of the road makes it impossible to continue using the property for some of the purposes to which it had previously been devoted so that its value is depreciated. The writer knows of an instance where a butterine concern recovered damages because the vibration of the building it occupied caused by passing trains interfered in some way with the manufacture of some of its products. Property used for residence purposes by the better classes of people is usually depreciated considerably by the construction and operation of a railroad in the immediate vicinity. Many cases could be cited showing the truth of this fact. It is, however, well known and needs no demonstration of proof to those experienced in railroad construction.

When damages of this kind are paid they are considered as a part of the cost of right-of-way whether the amount is paid to the owner from whom land is acquired or to owners of adjacent property.

These are the things that must be considered in determining the cost of acquiring a right-of-way. The thing that gives it value, however, is its suitability for railroad purposes. The fact that a line is located in the place where it may be built cheapest gives a value to the land equal to the difference in

cost of construction along that particular location and in the location that would be the cheapest after eliminating the present situation. In cities, station grounds and terminals derive value from their proximity to the greatest number of shippers; a condition that is usually coordinate with their nearness to the heart of the city.

The method of ascertaining the cost of acquiring such rights-of-way must be such as will reflect these factors. Where conditions are such that they do not possess many special features it may be assumed that a constant factor or function of the market value of lands may be used to determine the cost of acquisition for railroad purposes. When peculiar conditions exist sufficient to make the law of averages unreliable so that no definite multiple can be established to add to the market value, the land must be valued in such a way as to establish each factor of damage upon its own merits.

In valuations made heretofore it has been considered feasable to use a fixed multiple to establish the value of rural right-of-way and right-of-way and station grounds in small towns, but it has always been considered necessary to value separately the lands of each road in all large cities.

The method commonly used to establish the market value of lands adjacent to the right-of-way is to secure from the county records of transfers of land the prices for which all lands have sold recently within an area extending for a few miles each side of the railroad. From these figures the average price per acre can be determined for which land sold within this area. With this data as a basis, the engineer should view the tracts represented by the sales and compare the condition of the land with that of the land immediately adjoining and embraced within the right-of-way. If there have been sales enough to embrace all kinds of land to be found within the strip the average derived in this way will be practically the same as would result if all the land in the strip had been sold and an average derived therefrom. Usually, however, this will not be the case, so that some modification will be necessary to establish the true average value of adjacent lands. Owing to the fact that land values vary in each community it is better to consult with local residents who are informed as to condition and character of land and its value in their neighborhood. Their knowl-

edge will enable them to point out the differences that exist in various tracts of land and to make an intelligent estimate of the value of each tract as compared with the value of the lands actually sold.

The character of the land embraced within the right-of-way may or may not average the same as that of a more extensive area adjacent to the right-of-way. If it does, the average value of the larger area will be the same as the average value of the right-of-way. If the land is not the same then the price must be still further modified to fit the conditions actually existing. It is usually the case that land immediately adjacent to streams if not subject to overflow is of higher value than the land some distance away, being bottom land and more fertile than the higher lands farther away. It frequently happens that the railroads are located in the valleys of streams so that they embrace in their right-of-way a larger percentage of the most fertile land in the community, so that an average of sales including the higher ground some distance back from the stream would not represent the true value of the land occupied. The opposite conditions exist on lines located along the watersheds. All of these elements must be considered.

In some instances a method designated "Sales-Assessment" method is used. In this method an average of sales is obtained in the same way as above and in addition the assessed value of the same land is ascertained. The ratio that exists between the average of sales and the average of assessments is determined. This ratio is then applied to the assessed value of the tracts of land of which the right-of-way forms a part and the resulting figure is assumed as the true value of the land. This method, however, is not reliable because there is too great a variation between assessed and true value in different districts and in different tracts of land and the factor of inequality of character of the land itself acts in the same way as it does in the sales method alone. However, it is often worth while to utilize this method as a check upon the other.

In cities the value of lands used for railroad purposes must be judged from the standpoint of their worth for that purpose. The value of land in cities is in no wise dependent upon the character of the land. It depends wholly upon the adaptability of a particular site for the erection of buildings within

which to conduct business. This is dependent almost wholly upon its location. We cannot assume then as a premise that the value of lands used for railroad purposes are the same as the value of adjacent lands upon the ground that if they were not occupied by the railroad they would be utilized for the same purposes as adjacent property. Much of the property adjacent to railroads is put to uses that depend upon the proximity to a railroad. In other words, direct railroad facilities are a necessary adjunct to that particular kind of business. The existence of a railroad then is a factor that establishes the value of the adjacent property.

Take a section of a city where no railroad exists. The lots will be utilized for purposes that do not require railroad facilities. Let us assume that it is used for residences and such stores and shops as are usually found in residence districts. The value of these lots will be fixed by the use to which they are put. Let a railroad be projected through the district and an immediate readjustment of values will take place. Values will then be established upon the market estimate of the uses to which the land can be put after the railroad has been constructed and when the railroad undertakes to acquire the property it needs it will find that it must pay corresponding prices. It may in actual practice have been able to acquire some of the lots secretly before the knowledge becomes general that a railroad is to be built, but just as soon as it becomes evident that more than the normal amount of activity is taking place in the transfer of land in a district people realize at once that some interest is seeking to assemble property. By sizing up the situation and finding out how the property is being acquired real estate dealers can soon determine who is trying to acquire the land. Prices immediately assume a new level and the railroad must meet them or show its hand by resorting to condemnation suits. Owners refuse to place a price upon their holdings and demand an offer. Here then is where the value to the road for the purpose to which it desires to put the ground steps in and fixes the price. For that is the amount that it will offer for the land. It cannot pay more than this and will seldom be able to acquire the land for less. The owners will sell when they realize that they are offered top prices. The value of the adjacent land, however, does not stop here. It will not be fixed until

after the road has been built and the land actually begins to be acquired for other purposes for which it may now be adaptable. It may result that the market's estimate of the result was correct or it may have been incorrect; time only will tell.

When we come to place a valuation upon such lands after they have been occupied for some time we must consider the relation that the road's existance has to the value of adjacent property and be governed accordingly in determining the value of the tracts it occupies.

The discussion of the cost of reproduction thus far has been confined to the determination of the direct expense of the purchase price of the land and the cost of the material and labor involved in constructing the various items of property. Aside from these there will be certain indirect expenditures involved. It will be necessary to employ a corps of engineers to locate the line and superintend its construction. The expense occasioned thereby will be a charge against the property. The amount of this item will be closely proportional to the magnitude of the property and is estimated as a function of its cost, usually about four per cent. In purchasing the land there will be an expense involved in hiring men to acquire it and also an expense for fees for recording deeds, obtaining abstracts of title, etc. This has usually been estimated as from five to six per cent of the market value of the land. This ratio will vary somewhat, being lower in proportion to the value of expensive lands than in proportion to the value of cheaper lands. There will be more or less legal expense, so that a corps of attorneys will be employed and their salaries and expenses and the expense of litigation, witness fees, etc., must be charged against the construction. There will be required the usual corporation officers, president, secretary, manager, accounting and purchasing officers, etc., whose salaries and the expenses of their offices for clerks, etc., will all add to the cost of the construction. All such overhead charges and other corporate expenses of incidental nature are customarily added in the form of a percentage to the direct cost. The amount that should properly be required for the purpose is dependent upon various local conditions and must be decided for each particular case.

Another item of expense much larger in amount than any of these is the interest charge during construction. It will take

from one to three years time to construct the various lines of road. Some of the larger systems, of course, require a much longer period, but they will usually be considered as being constructed in separate parts, each of which will be considered as distinctly separate and as a unit itself for this purpose. During the time of the construction the money that is being expended will remain without return from such time as it is paid out as the construction proceeds until such time as the work is completed and the line put into operation. Due consideration must be given to this phase of the matter in the valuation of the property. In its subsequent application the valuation will be used to measure the earning power of the property as compared to the earnings of other forms of investment and interest on money loaned on bonds and mortgages, etc. In order that the comparison may be rational every form of investment must be reduced to the common standard of money. Money is capable of earning returns all the time. Any form of property investment then, in which a period of time will elapse between the time at which the investment is made and that at which returns begin to be realized must have added to the principal sum an amount of interest equal to the amount that would have accrued if the money had been loaned out at interest instead of having been invested in a property.

In the actual construction of a line payments are usually made monthly for the work as it progresses so that the determination of this interest charge requires that the rate at which the money will be paid out must be established and the computation made of interest for each month's expenditure from the time it is made until the line is completed.

Almost all the valuations thus far made have had an allowance included for contingencies. The engineers have recognized the fact that in going over a line of railroad and making a valuation based upon their inventory of what they found there would be many things that they would unavoidably miss. For instance they might fail to find underdrains, they might fail to allow for piling that actually existed under some bridge foundation, they would not discover every instance of rock excavation that existed, and, furthermore, in establishing their unit prices, they must base them as such upon the normal cost of similar things.

Many accidents are bound to occur, flood damages occur and so it is evident that the computations they might make if confined strictly to what they find by inspection as expressed in the inventory combined with these normal prices would fail to reflect the full cost of the property. To compensate for these unavoidable omissions they add this allowance for contingencies. Usually it is computed as a percentage of the total amount of all of the foregoing elements of cost.

The per cent allowed has varied from four to ten per cent. There can be no fixed rule. It will depend first upon the thoroughness and care with which the inventory is made and second upon the nature of the property itself as to how many things actually are missed inadvertantly by the inspector and as to how many elements of cost there may be about the property that are so concealed that they are actually undiscovered, no matter how great care is exercised. The engineer must be governed by his own opinion of what is compatible with the conditons as he finds them. For guidanee he should gather all the data possible, showing how close the average estimate of competent engineers on the cost of projected work comes to the actual cost thereof. He should not lose sight of the fact, however, that there are many variable factors not the least of which is the personal equation that exists in each case.

Up to this point we have dealt with the method of determining the cost of duplicating every element of the property just as we find it. We have assumed ideal conditions. In the actual history of any property we find that inevitable errors, which finite minds cannot avoid, were made and that subsequent to the initial period of construction these errors had to be corrected at some expense. For a period of years the roadbed will continue to settle and shrink so that expenditures must be made constantly to make good this settlement. As time goes on and these adjustments are made the value of the road increases and its cost has increased by the amount of money that has been expended in perfecting it and adjusting it to adapt it to the conditions it has to meet. In making an estimate of the cost of reproducing a property we must make allowance for these charges. If we did not we would assume impossible conditions.

For this purpose an allowance is made that is termed Adaptation and Solidification. Like many of the other factors of value

it is one for which no fixed rule can be laid down. The amount of value that may be justifiably ascribed to any property will depend upon its nature and the attention that has been paid to it by its owners. A careful examination of the property itself and a thorough study of its history will be essential in forming a conclusion relative to what the item amounts to.

In closing this article the writer will allude briefly to the subject of intangible values. Intangible values form an extremely elusive subject and as a result they present a field for most prolific speculation. Many persons have availed themselves recently of the opportunity to say something on the subject. Most of the opinions that have been expressed are mere generalities, however, and do not afford much assistance in solving the main question of how to determine the values. A method of determining the cost of developing the business of a certain concern has recently been proposed, which in substance consists in comparing the actual net earnings during each year of the plant's existence with a computed fair return upon the cost of reproduction of the plant during corresponding years. The amount of the excess of the fair return on the value over the actual earnings up to the time when the actual earnings became equal to the computed fair return was added to the physical value as representing the intangible value of the acquired business the company possessed. Such a method as this can at the most be applied only to such plants as have came into existence within recent years. It assumes two very important premises, the first of which is that the valuator has sufficient data, knowledge and ability to correctly establish what a fair return was during those years and second that the deficits were from such causes that it is legitimate to assume that there is no injustice in adding them as elements of value. No person of intelligence would presume to be able to go back into the history of a plant seventy-five or a hundred years old and derive any conclusive evidence therefrom concerning either of these factors. The way the subject must be treated is from the standpoint of what it would cost to establish a business under present conditions and under efficient management, judging efficiency by modern standards and not by the standards of the past and then decide what this established business is worth as an asset of the immediate future and as such a thing on

which the possessor is entitled to derive a return. The entire matter of fixing intangible values is one that must be determined by the application of common sense and good judgment of commercial affairs and not by fine spun theories of ethics.

It should be borne in mind that people enjoy many privileges, not because they stand the test of ethics, but because they have been found through the experience of ages to be the most feasible channels for the distribution of the rewards of human endeavor. Property rights have grown up on this basis. Under our code of business every one is entitled to avail himself of every privilege and gain for himself everything that his ability enables him to secure so long as he does not transgress the rights of others. Established custom defines the channels he may use. Under free competition price levels are commensurate with the average cost of production under the condition of using the least productive sources of supply that must be utilized to yield sufficient quantities of the commodities to supply the community's demands. One of the rights that our system creates is that of greater reward to him who avails himself of the advantageous facilities and by the exercise of superior aiblity produces more with such facilities as he has than his competitors do. It is best for the interest of all that such conditions should exist for therefrom springs the incentive that impells mankind to exert its utmost ability and from it results the progress of civilization.

In seeking to regulate the affairs of any form of property then a governing body cannot go to the extent of depriving that property of a privilege that other forms continue to enjoy. To do so would no only inflict immdiate injury upon the property in question but the reflex action that would result would effect the entire order of things and work harm to all property interests. Regulation must not interpose obstacles in the path of progress. It can only go to the extent of preventing the rights of the whole community from being transgressed by any of its constituent members.

The privileges that property enjoys are the sources of its intangible values. Going concern and good will values are the result of privileges the community is willing to accord a concern in reward for the effort it has exerted in affording that community a satisfactory source of securing something which it

wants. It can be seen then that the degree to which a property has become possessed of these elements of intangible value depends upon the capacity of the minds of its managers past and present to perceive wherein possible advantages exist and their capacity to avail themselves thereof. Furthermore, these things not only exist because of this capacity of the minds of the management, but they depend upon the state of mind of the community for their continuance. To undertake to establish and assign definite and fixed values to such things verges close upon the ridiculous.

No matter how we may seek to establish these values we find ourselves reasoning in a circle. The only tangible evidence we can find as to what they are is the earnings derived from the business. Yet if we are seeking to inquire into the reasonableness of rates, the fountain from which all earnings spring, we cannot gauge them by the values they have created and vice versa. We are at once confronted with the law of supply and demand. It may be that we are dealing with a monopoly so that this law is prevented from acting by the artificial control of the supply, but while we may discover that the supply does not limit the price as it should, yet the discovery of this fact does not get us any nearer to the solution of what the value created by the real demand would be.

My opinion of the whole matter is that we can never find a means of establishing what these values are prima facie, and that instead of attempting to regulate the prices of commodities with reference to the return their production ought to afford their producers, we must allow this phase of the matter to take care of itself and confine the regulation of the affairs of such concerns to the prevention of any artificial control of the supply. The value of the physical property should be established and made public. The property should be given credit for all elements of value such as have been created in it by the care and attention bestowed upon it by its owners. Where it is evident that the concern would have to devote time and money to the building up of such a volume of business as it now has the possession of such a business is a valuable asset for which the company must be given credit. Where by reason of the requirements of progress a concern is compelled to discard valuable property before its full utility has been

exhausted, it should be given credit for such investments just as if the items themselves were stil retained in service. All of these things, however, are physical elements in the sense that they are the measure of actual money investment. All such things and other things of similar nature should be included in the valuation and such values as are given to them should be determined with reference to the cost of their acquirement.

All other elements of value such as I have described which from their nature exist only because of the fact that the price for the products a concern has to sell as established by the demand therefor exceeds the cost of production, a condition that is created largely if not wholly through the skill and mental ability of the management to produce their product at costs below the average level and further to the state of mind of the community which is responsible for the desire to procure such products and in turn controls the demand can not be established. That where they exist they should have their reward is unquestionable, but to attempt to fix this reward with reference to some preconcieved notion of what these things represent in standards of value is not the way to go about it.

I believe that the proper place in the problem that this phase of the matter should occupy is in the question of determining what constitutes a reasonable return. It may appear that I am dodging the issue and that it would be futile to attempt to determine what is a reasonable return without first fixing the value upon which the return is to be based. I think, however, that I have made it clear that in the final analysis, values are not determined by cost of production, but instead are dependent upon the usefulness of the product to the consumer and are given expression in concrete terms by the demand. It is a phenomenon of our economics that among useful articles the cost of producing a thing always approximates its value, but this is merely a result of other phenomena and not a cause. It follows then from what I have said that in establishing what a reasonable rate is it must be fixed with reference to the value of the service to the consumer. Any return that results from prices that come within the limits of the demand must of itself be reasonable whether it results in greater profits than somebody else is able to secure or not. The part that the matter of the supply plays in the problem has to do with man's right to

an unrestricted opportunity to engage in any line of endeavor. No other man or community of men has the right to infringe upon this right. I will not enter into the question of matters of public policy and the police powers of the community, but it must be understood that these act to prohibit or confine some forms of activity and I refer only to such things as are not affected thereby or are within the limitations thereby established.

Our efforts at regulation then to be effective must be directed towards preventing the restriction of competition and where by reason of the nature of things competition does not exist, the effort must be to keep conditions the same as they would be if competition was a reality. The valuation of property and a study of the cost of production will be helpful for it will throw light upon the subject, but such things cannot be made the prime basis of regulation. To make them so will inevitably work harm instead of good for such action will result in destroying the incentive for the free exercise of ability, the foundation of all progress.

A Sewage Disposal Plant Built for a Private Residence at Cooperstown, New York

By M. I. Evinger.*

The problem of sewage disposal for a single residence differs from that of a municipality in that in the latter the disposal of the sewage is or will soon become mandatory, and under such circumstances expert services are usually obtained to solve the problem in a scientific and economical manner. In the case of

Fig. 2. View Showing Location of Sewage Disposal Plant and its Relation to that of the Residence Nearby.

sewage disposal for a single residence, the desirability of obtaining expert services has not been generally regarded as necessary and it has been during recent years only that very much attention has been given in a scientific manner to the study of the problem.

*Asst. Professor of Sanitary Engineering, Iowa State College.

Ever since its establishment the Engineering Experiment Station of the Iowa State College has been receiving a large number of inquiries for information concerning suitable sewage disposal plants for private houses. As a result one of the first lines of work taken up by the station was the designing, construction, and operation of such plants. The investigations were carried on by A. Marston, director of the Engineering Experiment Station, and F. M. Okey. The results of the operation of the experimental plants, conclusions drawn from the results of their operation, and details of a recommended design were pub-

Fig. 3. View Showing Location of Sewage Disposal Plant in Relation to That of the Lake. Note that the Concrete Slats Forming the Roof have been Covered Over with Earth Resulting in a Good Appearance about the Plant.

lished in Vol IV, No. VI of the Station bulletins. The plans of this design are show in Figure 1. Since its publication, the increasing number of inquiries received by the station for copies of the bulletin and in regard to the design, construction and operation of small sewage disposal plants for private or isolated residences, has been very gratifying. The inquiries have indicated not only a realization of the advantages to be obtained by the installation of modern sanitary conveniences in rural and suburban homes, but a very praiseworthy intention on the part of the owners to demand in their homes sanitary conveniences, which have hitherto been wanting, and the prop-

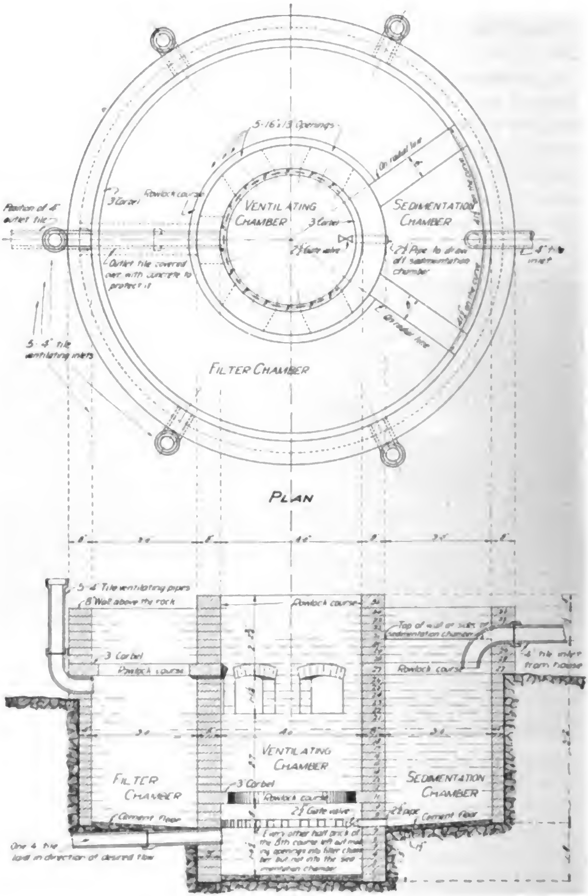


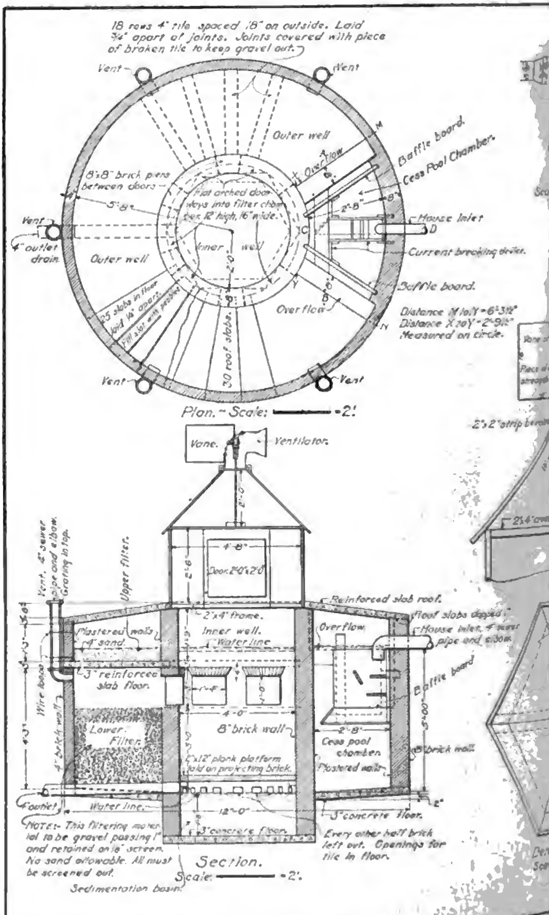
Fig. 4. Working Drawing Prepared from Plans of Recommended Design Shown in Fig. 1.

er disposal of the resulting sewage so that there will be no objection to it from a sanitary standpoint.

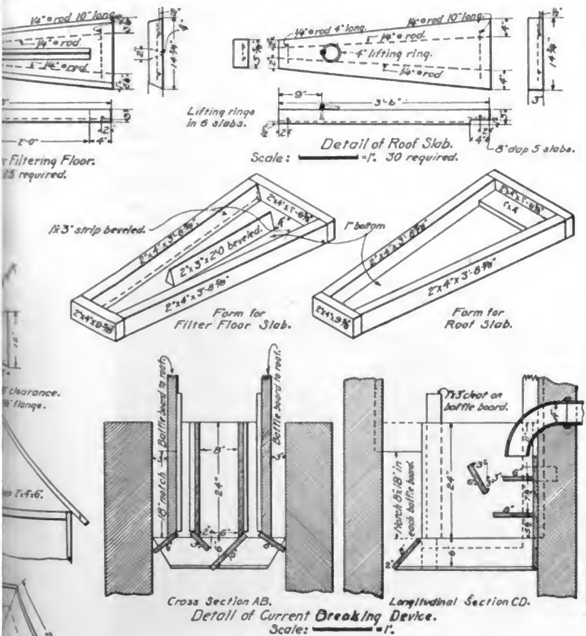
A number of sewage disposal plants for private homes have been built according to the recommended plan, which is described in detail in the above mentioned bulletin. The reports of their operation indicate uniform satisfaction. One plant, differing slightly from the recommended plan in some of its structural details, was built at the summer home of C. H. Bissell, near Cooperstown, N. Y., in the summer of 1911. The fol-

Fig. 5. View Showing Corbel Projections, One of the Openings Into the Ventilation Chamber, Baffle Boards in the Cesspool Chamber, and One of the Concrete Roof Slabs in Place.

lowing notes have been taken from letters received from Mr. Bissell, since deceased, and his brother, Amos Bissell, of Newark, N. J., describing their experiences in the construction and operation of the plant. Cooperstown draws its water supply from Otsego Lake, which is nine miles long and about four miles wide at its widest point, the lake being the headwaters of the Susquehanna River. The water is somewhat hard, but is comparatively pure, although there are a few private sewers emptying into it which should not be allowed. In 1910 the New York State Board of Health endeavored to induce the building authorities of Cooperstown to pass an ordinance prohibiting the



18 rows 4" tile spaced 18" on outside. Laid 1/4" apart at joints. Joints covered with piece of broken tile to keep gravel out.
Vent
Vent
Outer well
Overflow
Baffle board.
Cess Pool Chamber.
8"x8" brick piers between doors
Flat arched doorways into filter chamber 12" high, 16" wide.
5'-8"
2'-8"
Vent
House Inlet
4" outlet drain.
Inner well
Outer well
Current breaking device.
Baffle board.
25 slabs in floor laid 1/4" apart. Fill slot with pea gravel
Overflow
30 roof slabs.
Distance M to Y = 6'-3 1/2"
Distance X to Y = 2'-9 1/2"
Measured on circle.
Vent
Vent
Plan. - Scale: 2'.
Vane.
Ventilator.
Vent, 4" sewer pipe and elbow. Grating in top.
Upper filter.
Door 2'0"x2'0"
Reinforced slab roof.
Roof slabs dipped.
2"x4" frame.
Plastered walls
Inner well.
Overflow
House inlet, 4" sewer pipe and elbow.
4" sand.
Water line
3" reinforced slab floor.
Baffle board
Wire loops
4" brick wall
Lower Filter.
4'-0"
8" brick wall
2'-8"
Cess pool chamber.
8" brick wall.
2"x12" plank platform laid on projecting brick.
Plastered walls
Outlet
Water line.
12'-0"
3" concrete floor.
3" concrete floor.
NOTE:- This filtering material to be gravel passing 1" and retained on 1/8" screen. No sand allowable. All must be screened out.
Every other half brick left out. Openings for tile in floor.
Section.
Scale: 2'.
Sedimentation basin.



RECOMMENDED DESIGN
FOR
PRIVATE SEWAGE DISPOSAL PLANT

PLAN NO. 5

Scales: As shown.

Engineering Experiment Station
Iowa State College, Ames, Iowa. Jan 1910.
F.M.O.

No. 28.-8-A.

RE 1.

discharge of sewage of any kind into the lake and requiring that any cess pool or privy should not be less than 150 feet distant from the lake shore. This ordinance was not passed, but it served as a warning to Mr. Bissell to endeavor to so take care of the sewage from his residence as never to get him into trouble with the authorities later on.

The house is located on a side hill and at a distance of about 150 feet measured in a straight line along the surface of the ground to the lake and about 50 feet above the lake. Figures 2 and 3 show very clearly the location of the sewage disposal plant in relation to the house and to the lake. Mr. Bissell had a draughtsman make a working drawing (see Fig. 4) from the

Fig. 6. A More Detailed View of the Baffle Boards in the Cesspool Chamber.

recommended plan, (see Fig. 1), and in it incorporated certain features which may be noted in the following quotations from a description furnished by Mr. Bissell a short time after the plant was built:

"If you will study the drawing you will note that each course of brick is numbered so that an ordinary mason can follow the drawing without trouble. You will also note that we projected out a 3 inch corbel made from a rowlock course near the bottom of the ventilating chamber to hold a plank to

support a man when cleaning, and also another corbel just above the ventilating openings leading from the ventilating chamber to the filter chamber to hold the reinforced concrete slabs which support the sand filter.

"In my case it was easier to build reinforced concrete slabs in segmental form to support the sand filter than to cast this floor in with slots in it.

"I had only unskilled Italian labor, none of them could speak English and as I could not be there myself, depended upon a local engineer to look after this work and the results obtained from a construction standpoint were all that I had hoped to

Fig 7. View Showing Opening Into the Ventilator and General Appearance of Chambers Before the Filtering Material was Placed.

get. I think the photographs will clearly show the neatness with which the reenforced slabs for the job came out of the molds. The slabs to support the sand filter were equally good and the whole plant is a source of great satisfaction to me."

Mr. Bissell had the walls laid of hard burned brick, 8 inches thick and plastered with a one to three Portland cement mortar both outside and inside, the coat being one-half inch thick and the work well done. However, when the plant was finished and put in operation, leakage developed between the cesspool chamber and the adjoining chambers. The plant was operated during

the month of September, 1911, then drained and allowed to stand until May, 1912, when a plaster of one part Portland cement to two parts sand and mixed with water containing dissolved alum, was applied to the walls of the cesspool chamber. This was done in accordance with the recommendation of Mr. Bissell and resulted in stopping the leakage. As a result of Mr. Bissell's experience in the construction of the plant, he recommends the use of hard burned brick because of their being more impervious, that the mortar be mixed one to two and that the water used for mixing should contain ten pounds of alum dissolved in each barrel of water. Mr. Bissell surmised that the use of alum in the water used for construction of the cesspool chamber would form, with the soap contained in the sewage, a very much more impervious wall even than it would if used against clear water. He also recommends the lining of the cess pool chamber with a concrete wall 3 inches thick.

The cost of constructing this plant was as follows:

Labor—		
Excavating	$ 21.83	
Mason work	60.60	
Carpenter work	25.20	
Laborers' work on covers	2.70	
Lavorers' work obtaining gravel	12.10	
		$122.43
Materials—		
Cement, 80 bags at 42½c	$ 34.00	
Tile	2.00	
Lumber	5.00	
Reinforcing bars	3.00	
Covers for plant	5.00	
		$ 49.00
Total		$171.43

Mr. Bissell is quoted again as follows:

"You will note that this does not include superintendance and it is altogether more than it would cost if a farmer were to build it himself, hiring a brick mason to do the mason work and a carpenter to do the carpenter work, providing the farmer did his own excavating and hauling and furnished his own labor. My costs were based upon a labor charge of 22½ cents

per hour for Italian labor and 37½ cents per hour for carpenters and bricklayers. The excavation was in soft shale rock, very difficult to excavate, as we could not drill and blast, because of the nature of the rock, and, on the other hand, it was very hard to pick loose. The whole shore of the lake is underlain with this shale rock more or less disintegrated, which is covered with from 8 to 15 inches of top soil.

"The effluent is led away down the hill a few feet and discharged into a blind ditch which runs parallel with the lake shore and about 100 feet distant therefrom. This blind ditch

Fig 8. View Showing Interior of Completed Plant with Roof Slabs in Place, One of Them Containing an Opening for Inspection Purposes.

was excavated through the rock to a depth of three feet and a four-inch tile laid loosely in same. Its total length is about 150 feet and the ditch was then back filled with the shale rock which had been excavated. As this shale rock is more or less porous, the area so provided seems to be sufficient to take care of the effluent."

Mr. Amos Bissell in a recent letter stated that after the leaks in the plant were repaired in May, 1912, that the plant was used from that time on until October 1, 1912, and that during the month of June, 1912, there was quite a little odor from the exhaust air soil pipes but as soon as the aerobic bacteria were de-

veloped sufficiently this odor ceased and that no further trouble was experienced. He also stated that the affluvia was clear and had practically no odor, and that if there is an odor to it it is as if a drop of perfume was put into a quart of water.

The question of cheapness, as between concrete and brick, is one to be decided in every case by local prices. Undoubtedly concrete would be cheaper if it were not for the cost of the forms. It is very probable that in most cases it would be cheaper to lay up the walls of brick instead of to make them of concrete on account of the cost of the forms.

Those who are interested in the detailed design, construction, and operation of the above described type of sewage disposal plant for private residences, the general treatment of which this article was not intended to cover, can obtain the bulletin issued by the Engineering Experiment Station on "Sewage Disposal Plants for Private Houses" by writing to A. Marston, Director, Ames, Iowa.

The Removal of Iron from Iowa State College Water Supply

By O. M. Smith.*

Chemical analyses of the water used at the Iowa State College from the two shallow wells near the Central heating plant show that it has a very variable composition from week to week. Tests made show it to be a good water from a sanitary standpoint and low in bacterial count. The greatest objection is the large quantity of iron which the water contains in the form of soluble iron salts, ferrous carbonate $Fe(HCO_3)_2$ and an insoluble iron hydrate $Fe(OH)$. Most of the iron in the ferrous state—unsaturated with oxygen—coming in contact with the air is oxidized to the ferric condition $Fe(OH)_3$, when it precipitates as a rusty colored sediment. These fine particles of rust, as they are commonly called, gradually gather together into large flocculent flakes which slowly settle, if undisturbed, leaving the water clear and almost free of iron. In all alkaline mineral waters which contain large quantities of iron, i. e., greater than two parts per million, it is this precipitation which causes so much trouble and the water will always be rusty or turbid unless sufficient sedimentation is allowed or adequate filters installed. The removal of these disagreeable features in a water supply is a process consisting of chemical reactions and mechanical separation of solids from liquids.

The chemical treatment consists in the aeration or mixing of the water with air; this oxidizes the iron and removes many gases dissolved in the water, the most common being hydrogen sulfid. Before taking up a detailed discussion of the method employed for so aerating the water at the Iowa State College, a brief discussion will be given of the general factors to be considered.

There are several physical factors which have to do with separation of the hydrate of iron from water. The most important are as follows:

*Assistant Chemist Engineering Experiment Station.

First: A precipitate will settle with more rapidity in a quiet solution, therefore sufficient storage is needed.

Second: Enough time must be allowed for the fine particles to fall below the opening of the outlet pipe. A saving in time is accomplished in large reservoirs by having floating outlets. In this case, the level of the water falls at a slightly slower rate than the settling of the precipitate, thus insuring a clear water.

Third: The character of the precipitate has much to do with the speed of clarification. A crystalline dense solid will settle more rapidly than a light gelatinous precipitate. Iron precipitated from water as hydrate is a light flocculent material which is slow in settling. In clarifying water, iron hydrate is of much value since it entrains organic matter such as bacteria and other micro-organisms, also finely divided mineral matter such as clay and silt. Thus a speedy coagulation of the fine particles of hydrate is to be favored.

The importance of these factors is emphasized in the efficiency tests of the system now in use at Iowa State College.

The system proper comprises an aerator and reservoir. A large cone-shaped hood contains the aerator, which consists of a circular basin 6 feet by 6 inches in diameter by 4 inches deep and a circular trough 1 foot by 9 inches in width by 4 inches in depth. The water is forced by the centrifugal pump in the well to the upper basin where it overflows into the trough, from thence it overflows into a basin and on into a 140,00 gallon reservoir by way of a channel. In all, the water falls 3 feet, 1½ feet at each fall and is fully aerated.

This oxidizes the iron to the hydrate and it is expected to settle out in the circular reservoir with the inverted cone-shaped bottom and be discharged by a clean out-pipe. The clear water is removed by an outlet pipe placed 6 feet above the bottom. The last four or five years have seen an excessive demand for water and the capacity of the present plant has been very much exceeded. As a matter of fact, the water has not been detained long enough in the reservoir to permit of the settling of the iron, silt, etc., hence it has been and is depositing in the distribution system causing a marked turbidity.

In 1911, Mr. Arthur Woodman and B. B. Hanson made an experimental investigation of the iron removal from the college water supply. The data for table No. 1 was obtained from them

by the Engineering Experiment Station. Their results show a very efficient aerator, but they obtained no data on the efficiency of the settling basis. To obtain these results, samples of aerated and unaerated water were obtained with the proper precautions and allowed to stand exposed to the air under conditions similar to those met in actual practice. The samples were analysed after periods of 12 and 24 hours and the amounts of iron calculated in parts of iron per million.

TABLE I.

Test No.	Condition of Sample	Total Iron	Iron in Solution after Standing		Per Cent of Iron Removed in	
			12 hrs.	24 hrs.	12 hrs.	24 hrs.
1	Aerated	2.5	.75	.15	94	70
	Unaerated	2.5	.50	.15	94	80
2	Aerated	7.5	1.7	.85	89	77
	Unaerated	7.5	.2	.1	99	97
3	Aerated	5.6	.4	.4	92	93
	Unaerated	5.6	.2	.1	98	96

These data show that aerated water settles and is practically free of iron in twelve hours, while the unaerated requires more than twice as long a period. The percentage of iron removed is a measure of the efficiency of the aeration.

In determining the efficiency of the settling basins, several samples of water were taken from the well, reservoir, mains and tank and analysed for iron. The results are shown in Table II. It will be seen that the aerator had an efficiency of 94 per cent which is as much as can be expected. After the iron is oxidized it must be removed from the water by sedimentation. The table shows that only 26 per cent of the iron settles out in the reservoir, while 64 per cent deposits in or passes through the mains. This means that the efficiency of the settling basin is only 26 per cent instead of 90.93 per cent. The tables also show why any slight disturbance in the pressure throughout the system causes the water to become turbid, the degree increasing with the violence of the disturbance. Assuming that 105,000 gallons of water are used per day, there is deposited

in or passes through the mains each day 7.3 pounds of iron oxide or 1 and 1-3 tons a year. The larger per cent of this sediment or rust is continually being washed out with every little increase in flow and causes much annoyance to the user of water.

TABLE II.

	Total Iron	Iron in Solut-ion	Iron in Suspension	Amount of iron oxidized by areator (rendered insoluble)	Percent of Iron (compared to soluble Fe) rendered insoluble Efficiency of Aeration	Iron Removed	Percentage of Iron removed (compared to total amount of Iron) Efficiency of System
Water direct from well..	8.8	7.1	1.7				
Aerated water from reservoir..................	6.5	.4	6.1	6.7	94%	2.3	26%
Aerated water from main	.9	.2	.7	6.9	97%	6.9	90%
Aerated water from tank..	.6	.1	.5	7.	99%	8.2	93%

From the above data it can be readily seen that the capacity of the reservoir is much too small for the present demand. The capacity of the system must be increased or filters installed befor any improvement can be expected. A sedimentation reservoir is prohibitive from the cost standpoint, bulky and inefficient. Some design of a sand filter is undoubtedly the best solution. If the present water supply is passed over an aerator, then through channels into basins where it is permitted to stand for a short time to allow the precipitated iron hydrate to gather in large flakes, it can be easily and efficiently filtered by a bed of sand of appropriate size and from 1½ to 2 feet deep. The precipitation coagulation and filtration of iron together will remove all the sediment and rust, and materially reduce the bacterial count. Any of the standard designs of filters with arrangements for washing the sand by use of air and water or by water alone, will be all that is necessary.

THE IOWA ENGINEER

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Official Organ of the Iowa Brick and Tile Association and of the Iowa Association of Cement Users.

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EDITORIAL

The extended discussion and agitation over engineering has ended for the present at least. The changes proposed by the State Board of Education will not be carried out and both engineering schools will continue their work as before. The wisdom of the course remains to be seen. A great many benefits, however, have resulted from the airing of the situation espe-

cially as far as Ames is concerned. Among other things, it has been clearly brought out that the Ames engineering school is really serving the needs of the people of the state. Engineering education which does not serve any practical purpose in increasing the production of Iowa, or in bettering the condition of her society, certainly is not justified. The Engineering Division at Ames, has, through its experiment station, and through the work of its graduates, ever attempted to perform this function. The fact that the present legislature has seen fit to appropriate $25,000 per year for a system of industrial education centered at Ames, will enable the college to greatly extend its field of usefulness.

A large responsibility devolves itself upon those who will have to inaugurate this new scheme of industrial education. The money appropriated should be used so as to bring the largest returns. Possibilities for education will be opened up to thousands of boys and men engaged in the industries who cannot avail themselves of high school and college training. To bring these persons to an understanding of their opportunities and to actually start them in classes will require an immense amount of effort. We cannot but believe that the great plans will be worked to a successful conclusion and that the state will be amply repaid for projecting the work of the engineering division into every shop and factory.

As we leave our place as editor of this publication, we wish to thank those who have assisted us so ably during the present year. Members of the staff with the exception of the editor and business manager, receive no credit for their work on the magazine. Any improvements that have been made in the "Iowa Engineer," are due in a large part to the active cooperation of these men. The editor and business manager wish to take this opportunity of expressing an appreciation of their services.

ALUMNI NOTES

J. H. Burlingame, M. E. '11, who was one of Ames' strongest debaters while in college, has recently been appointed branch manager for the C. A. Dunham Co. at Kansas City, Mo.

Bryce Hutchison, Min. E. '09, has disposed of his real estate at La Feria, Texas, and will again take up work in his profession.

H. E. Robinson, Min. E. '08, in a letter to Prof. Beyer, states that he is just recovering from a siege of sickness. When well enough he intends to go back to either Jarbridge or Contact, Nev. His present address is Twin Falls, Idaho.

R. L. Howes, M. E. '11, a Tau Beta Pi man, is at present teaching in the M. E. department at the University of Pennsylvania. He reports that he has had a successful year there.

Owen T. Barry, M. E. '09, is now secretary of the Central Iowa Retail Lumberman's Association with headquarters at Cedar Rapids, Iowa.

A. G. Baker, C. E. '11, is city engineer of Hampton, Iowa.

F. S. Dewey, E. E. '08, is now assistant superintendent of the Peoples Light Co. at Davenport, Iowa.

W. L. Fulton, C. E. '06, is chief draughtsman of the Omaha & Council Bluffs Street Railway Co. at Omaha.

H. G. Coutts, C. E. '10, has left the Wells Construction Co. of Chicago and is superintendent of construction for Geo. C. Nemmons Co. on the new Reid, Murdock & Co. building in Chicago.

W. E. Reynolds, C. E. '11, who has been with the Waddel & Harington Co., consulting engineers of Kansas City, Mo., is working for the same firm on bridge construction in British Columbia. He expects to return to Kansas City soon to start designing a bridge to be built in California which will cost nearly two million dollars.

W. E. Wilbur, C. E. '11, is also with the Waddell & Harrington Co. He has the same class of work as Mr. Reynolds.

Index to Volume XIII.

THE IOWA ENGINEER

Vol. XIV. No. 1. October, 1913

THE IOWA ENGINEER

VOL. XIV. OCTOBER 1913 NO. 1.

CONTENTS

PUBLISHED MONTHLY DURING THE

COLLEGE YEAR BY

STUDENTS OF THE DIVISION OF ENGINEERING

IOWA STATE COLLEGE, AMES, IOWA

Annual subscription $1.00, Single Copies, 15 cents.

THE BLACK HAND.

The most valuable asset that an engineer may possess is courage. Patience, skill, resourcefulness, tact and judgment, all these may be added unto the engineer who possesses courage: but the greatest of these is courage.

The human mind and, through it, human endeavor have no limitations. We are capable of more than we believe we are. What we thought was impossible has become reality. The dreams and romances of the past have become the commonplaces of the present. By courage the engineer has produced the sub-marine, the air-boat and the wireless telegraph. Engineers of strength and courage laid a belt of steel across prairie and forest, mountain and desert to connect ocean with ocean and make possible the wonderful transportation system that we have today. The conquests of the future are to be more glorious than those of the past. Yet more wonderful things than these shall we do if we but have the courage.

There is an enemy, however, which in a moment may destroy the hopes and visions of a thousand years. The black hand of discouragement looms up in the soul of man to defy further advance. It has halted many an engineer at the verge of a great victory. The reason men fail is because they give up too easily. Engineers and men, apprentices as well as professionals in the high art of living, BEWARE THE BLACK HAND!

Substructure of Osage River Bridge on the St. Louis, Kansas City and Colorado Railroad Length of Main Span 375 ft. from bed rock to top caping. F. R. Lyford, B. C. E. '95 Resident Engineer in charge

THE IOWA ENGINEER

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Design of Machine Members with Eccentric Loads.

N. LEERBERG, B. S. in M. E. '11.

In the design of beams, or machine members subjected to bending the rectangular section presents the simplest case. The neutral axis passes through the centre of the section and, in such materials as are usually employed in machine construction and which approximately follow Hooke's Law, the pressure centre is located $\frac{2}{3}$ the distance from the neutral axis to the outer fibre. This relation is shown graphically in fig. 1, in which horizontal distances of the shaded area are proportional to the stresses at these points. It must be noted that the centre of pressure falls upon the centre of gravity of the shaded area, which is usually termed the "modulus figure." For the design of such a beam, or in fact, any beam of symmetrical section, the pressure center is not required, but such a simple case best illustrates the case under discussion.

A slightly different case is found in the I beam. The centre of pressure now falls nearer to the outer fibre, but may be located by the same principle used in the preceding case. Reference to fig. 2 will illustrate this point. The section is divided into as many horizontal laminae as may be required (in this case two) and all corners of these laminae projected onto the horizontal base line X*b*, giving the points a, b, c, and d. These points are then joined to the centre "O" by straight lines whose intersections with the horizontal divisions determine points in the modulus figure. The centre of gravity of this area then determines the pressure center. But supposing that the section under consideration is that of a Z beam a very different case obtains. Besides bending around the axis x—x (fig. 3) there is now also a moment bending to produce buckling about the axis y—y. It is the determination of

this buckling moment, when occurring in complicated frames, which is here attempted.

The section here reproduced is that of a large 3600 ton Steam-Hydraulic Shear being built for the Indiana Steel Co. and to be installed at Gary. The shear is capable of cutting a 26"x68" section, and will be the largest shear of its kind.

The base will be subjected to a direct shearing force and an additional side thrust due to the bending of the fibres in the

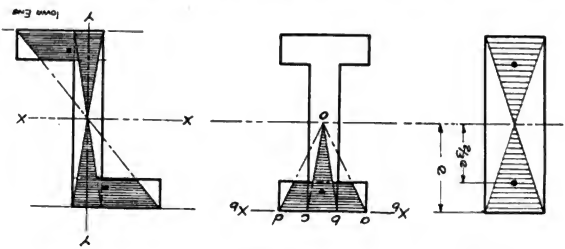

Fig. 1. Fig. 2 Fig. 3

process of shearing. The forces will then be as indicated in fig. 4, giving a resultant of 7,630,000 lbs. acting at an angle of 7° 30' to the vertical. The distance between shear columns is 10' 6", and the cutting edge is 68" long. The base is, therefore, in fact, a beam having 10' 6" between supports, and uniformly loaded for a distance of 68" in the centre, giving unloaded parts of length "aL" at both supports. We then have a maximum moment of

$$M_{max}=\frac{WL(1+2a)}{8}$$

$$\text{but } a=\frac{\frac{126-68}{2}}{126}=.23.$$

Substituting the values in the formula,

$$M_{max}=\frac{7,630,000\times126\times1.46}{8}=175,300,000 \text{ in lb.}$$

The neutral axis will, of course, pass normal to the resultant

force. Now divide the section into elemental area, the inertia moment of which may be readily found. Several elements will be rectangular, but oblique to the neutral axis. For such shapes refer to formulae found in the "Cambria Steel Co." Handbook. In order to save repetition and to facilitate calculations it will

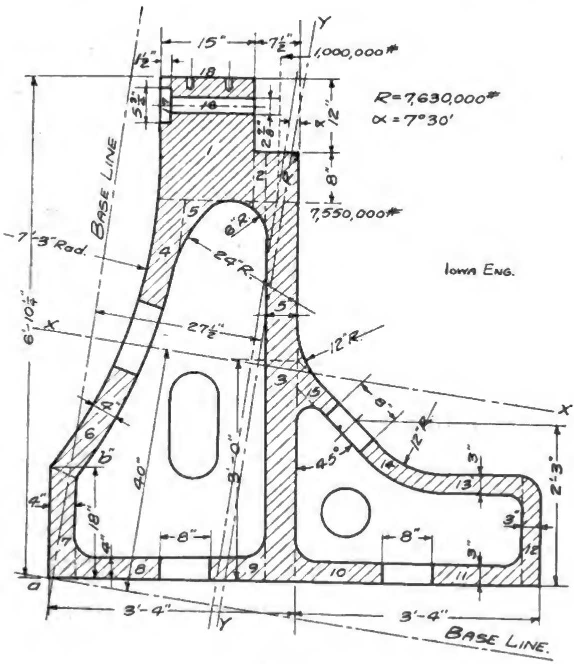

Fig. 4

be found very convenient to put all the data in a form similar to Table I. In dividing the section into elemental areas good judgment should be exercised. Inaccuracies near the neutral axis count but little, while inaccuracies near the outer fibres effect the result most seriously.

Table I. Data of Section about axis x—x.

No.	b	h	F	x	Fx	Ig	d	Fd2
1	15	20	300	76	22,800	9,850	36	390,000
2	2.5	10	25	70	1,750	204	30	22,500
3	5	60.25	301	41	12,350	89,000	1	301
4	4	17	68	56	3,800	1,640	16	17,400
5	5	8	20	63	1,260	71	23	10,600
6	4	19	76	27	2,050	2,240	13	12,850
7	4	17	68	9	612	1,600	31	65,500
8	14	4	56	3	168	88	37	76,800
9	9	4	36	7	252	51	33	39,200
10	14	3	42	8	336	42	32	43,000
11	14	3	42	12	504	42	28	33,000
12	3	18	54	20	1,080	1,420	20	21,600
13	18	3	54	26	1,400	64	14	10,600
14	9	3	27	27	730	108	13	4,550
15	8	3	24	37	890	78	3	216
16	2⅞	13½	— 39	81	—3,160	— 35	41	—65,600
17	1½	5¾	— 9	80	— 720	— 23	40	—14,400
18	2½″	2½	— 6	84	— 504	— 3	44	—11,650
			1,139		45,598	106,437		656,467

The neutral axis is determined by the formula:

$$Z = \frac{F_1x_1 + F_2x_2 \ldots.}{F_1 + F_2 \ldots.} = \frac{\text{Sum of Fx column}}{\text{Sum of F column}}$$

Hence,

$$Z = \frac{45,598}{1,139} = 40'' \text{ from base line.}$$

The values of "d" are now readily obtained from the relation:

$$d = \pm x \pm z.$$

The moment of inertia is

$$Iz = Ig + Fd^2$$

$$= \text{Sum of "}Ig\text{" column} + \text{Sum of "}Fd^2\text{" column.}$$

Hence,

$$Iz = 762,904 \text{ in}^4.$$

and the "Section Modulus" for tension is

$$\frac{762,904}{40} = 19,070 \text{ in}^3.$$

The fibre stress at "a" will therefore be

$$pf = \frac{175,300,000}{19,070} = 9,200 \text{ lb./in}^2.$$

But, from the shape of the section, it is evident that there

will also be a buckling moment tending to further increase this fibre stress. It is readily seen that the corner "a" will take the maximum stress. A base line is therefore drawn through this point and the neutral axis and moment of inertia with respect to that axis determined as before. The data is set down in Table II. It appears from the data that the moment of inertia is 514,644 in^4. The section modulus for tension then becomes

$$\frac{514{,}644}{27.5} = 18{,}700 \text{ in}^3.$$

It now remains to find the moment which this section must resist. The centre of tension will always fall on an axis parallel to the y—y axis and passing through the centre of gravity of the tension side; and the same relation also holds for the compression side. The sum of the tension forces need not be equal to the sum of the compression forces, nor need their moment

Table II. Data of Section about axis y—y.

No.	b	h	F	x	Fx	Ig	d	Fd2
1	20	15	300	14	4,200	7,000	13.5	54,700
2	10	2.5	25	24	600	13	3.5	306
3	60.25	5	301	32	9,650	14,700	4.5	6,100
4	17	4	68	10	680	91	17.5	20,800
5	8	5	20	14	280	28	13.5	3,650
6	19	4	76	3	228	110	24.5	45,750
7	17	4	68	0	0	93	27.5	51,300
8	4	14	56	10	560	910	17.5	17,200
9	4	9	36	30	1,080	240	2.5	225
10	3	14	42	46	1,930	680	18.5	14,400
11	3	14	42	69	2,900	680	41.5	70,500
12	18	3	54	76	4,100	41	48.5	127,000
13	3	18	54	64	3,440	1,450	36.5	72,000
14	3	9	27	51	1,380	110	23.5	14,900
15	3	8	24	38	915	122	10.5	2,640
16	2⅞	13½	— 39	14	— 546	— 580	13.5	— 7,100
17	5¾	1½	— 9	6	— 54	— 2	21.5	— 4,150
18	2½	2½	— 6	13	— 78	— 3	14.5	— 1,260
			1,139		31,395	25,683		488,961

arms be equal; but the two moments are always equal. It is therefore sufficient to locate one centre of pressure. In this case the compression side presents the simplest section, and will therefore be chosen. The distance of the neutral axis from the base line is

$$Z=\frac{300\times14+25\times24+175\times29+68\times10+20\times14-39\times14-9\times6-6\times13}{300+25+175+68+20-39-9-6}$$

$Z=19''$

as the distance from the y—y axis $=27.5-19''=8.5''$.

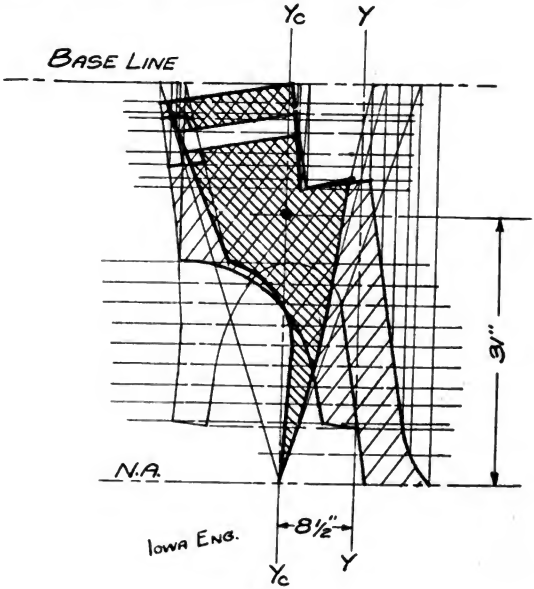

Fig. 5

All fibres equidistant from the neutral axis have the same resisting ability. It will therefore be found convenient to block the section as shown in fig. 5. The resulting section is now treated by the method illustrated in fig. 1, 2 and 3. To save confusion only a few of the lines are shown in the figure. It is needless to say that in actual work the figure should be drawn to as large a scale as convenient. The finely cross-hatched figure

represents the modulus figure, and the intersection of its horizontal gravity axis with the $Yc—Yc$ axis determines the centre of pressure.

This gravity axis may be found mathematically, as by balancing on a knife edge. But if the modulus figure is very complex it may be convenient to find its corresponding modulus figure. The area of the first and second modulus figures are then found by means of an integrating planimeter.

Let A=area of first modulus figure.

a=area of second modulus figure.

g=distance of gravity centre from neutral axis.

d=distance of base line from neutral axis.

Then,

$g=\frac{ad}{A}$, or 31″ in the present case.

The maximum moment was found to be 175,300,000 in. ℔. But only half of that is taken by the compression side. The total force at the pressure centre is therefore,

$$\frac{175,300,000}{2\times31}=2,830,000 \text{ ℔.}$$

The buckling moment about the axis y—y (fig. 5) then becomes,

$$2,830,000\times2\times8.5=48,000,000 \text{ in. ℔.}$$

And the stress due to this moment is,

$$Pt=\frac{48,000,000}{18,700}=2,570 \ \#/\text{in.}^2.$$

At the point "b" Pt would be somewhat greater, but at the point "a" the two stresses add up directly, becoming

$$9,200+2,570=11,770 \ \#/\text{in.}^2.$$

Had the flat bottom not been required for the foundation the point "a" could have been well rounded and thus the stress greatly reduced.

It will be evident that this graphical method is applicable to any section that may occur. Many other useful applications might be shown, which, however, are beyond the scope of the present article. But for those who desire to seek further, attention is called to "James Mech. Engineer's Pocketbook," in which are found graphic solutions for the centre of gravity, the

moment of resistance, and the moment of inertia of any section. A very excellent article on the graphic solution of the moment of inertia of machine frames is also found in the "Machinery's Reference Series."

Engineering Extension at the Iowa State College

BY R. B. DALE, B. M. E.*

It is imperative that the beginners in any craft, trade or other class of skilled workers shall have adequate instruction if the trade is to continue to exist, progress and improve. Under the old guild system and the old time indentured apprentice systems the organized trades themselves provided for the instruction of the beginners. When the factory era came in and brought with it a new industrial outlook, the guilds were outgrown and the systems of indentured apprentices no longer satisfied the new conditions. For a time the burden of instruction was left with the beginner himself. A democratic spirit in America asserted that every man was born free and equal and, therefore, he had an equal chance with his fellow to share the opportunities of life. The beginner in a skilled trade or occupation was left to claim his opportunities as he saw fit. Education and self instruction came hard The individual workman who possessed valuable knowledge of his trade was loathe to impart it to the beginner. His philosophy was: "I had to work hard for the skill and knowledge I possess. Let the beginner dig for his information." It was a case of "every man for himself."

Meanwhile, through those splendid beginnings, the public school system was being built up. Realizing the imperative need of the education of the young the pioneers were quick to establish schools and colleges. The public school system became the pride of the people. As a public institution our public school system is something of which to be proud.

The business of the government of the United States is the people's business. They not only construct their institutions

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but they criticise them. A few years ago the critics were surprised to find that less than thirteen per cent of the young people of the country were taking advantage of the public schools. The other eighty-seven per cent receive very little benefit from our splendid and elaborate public school system. The trouble was that the schools were established to fit the institutions of higher education and the industrial workers of the nation were neglected.

J. W. Parry K. G. Smith R. B. Dale

Within recent years we have begun to provide institutions for this large number of students who are not able to take advantage of the public schools. We are just beginning our work in industrial education. Realizing the situation in the State of Iowa and knowing that a large proportion of the people were engaged in industrial pursuits, the Thirty-fifth General Assembly of the state made an appropriation to provide for engineering extension work at the Iowa State College. It was undoubtedly the intention of the Legislature to provide instruction for the industrial classes in our cities. Iowa is not only an agricultural state, but it is also a manufacturing state. According to the report of the Iowa Manufacturers' Association, the value of our manufactured product is something over three hundred and fifty million dollars per year. This value represents largely the labor expended upon raw materials. It is fitting, therefore,

that the state should assume some of the responsibility of the training of these workers.

The work to be done by the Department of Engineering Extension at the Iowa State College, is of four kinds. The first and it would seem, the most important branch of the work is to

Two-year-Engineers working in pattern shop.

be the local classes in the cities. It is expected that these classes will consist of the industrial workers. Our organizer Mr. E. S. Shortess, is now in the field and is interesting workmen in these classes. Classes have already been started in Cedar Rapids and they will soon be started in Waterloo and other cities. The following subjects are offered: Shop Arithmetic, Mechanical Drawing, Gas Engines, Heat, and Heating and Ventilation. The local instructor meets these classes one or two evenings a week. If the student attends the class meetings and does the required work he is awarded a certificate upon completion of the course.

An attempt will be made in the industrial centers of the state to establish schools upon the continuation plan. Such schools have been particularly successful in Milwaukee under the supervision of the University of Wisconsin and the Iowa State College anticipates a similar success in Iowa. Such schools owe

their advantages to the fact that the student is fresh and not worn out by the day's labor in the shop. The continuation plan is that in which the employer permits his young workmen to attend these classes on the company's time. The employer's reward is obtained in increased loyalty, contentment, and the greater efficiency of his workmen.

The second kind of work to be done by the extension department consists of correspondence instruction. The field of correspondence work is not limited by either time or location. The success of correspondence instruction has been demonstrated. Dr. Wm. R. Harper may be said to be the father of modern correspondence instruction in the United States. In the year 1880, he instituted the first correspondence course. In 1892 the University of Chicago instituted correspondence instruction as a feature of its university extension work. About the same time the now familiar privately owned correspondence schools were founded. Among the prominent public institutions now giving work by correspondence instruction are the University of Chicago, University of Wisconsin, Pennsylvania State College, and Iowa State College. The correspondence work of the Department of Engineering Extension will take advantage of all of the best known methods of correspondence instruction. Texts especially adapted for correspondence study will be used and the criticisms will be constructive rather than destructive and discouraging.

It is expected that the correspondence work will be of two grades: first, instruction for students who are prepared for work of college grade in engineering and, second, instruction intended especially for workers in the trades. For the first class, courses will be offered in the following subjects: Structures, Steam Boilers, Heat, Drafting Room Practice, Heating and Ventilation. Mechanics, Mechanism, Direct Current Machinery, Electric Meters. Agricultural Engineering and Ceramics. For the tradesman the following courses are offered: Elementary Shop Arithmetic, Advanced Shop Mathematics, Carpenter's and Builder's Arithmetic, Builder's Estimating, Elementary Shop Drawing, Advanced Shop Drawing, and Carpenter's and Builder's Drawing. In addition the following courses in business engineering are projected: Retail Selling and Store Management,

Elementary and Advanced Cost Accounting and Plant Management.

A third important feature of the extension work is the two year trade school course along engineering lines offered to students in residence at Ames. It is to be understood that a trade school in the strict sense of the term is a large city proposition. The successful trade schools are maintained in cities of fifty thousand or more inhabitants. A young man learning a trade does not feel that he can sacrifice a considerable amount of money and time to attend a trade school at a distance from his home. On the other hand it is recognized that many of the skilled occupations related to engineering require a fundamental knowledge of mathematics, english, chemistry, physics, drawing and shop work which the college may well supply. The schedule of courses includes such practical subjects, as work in cement products, road making, power plant operation and the application of electricity. A certificate is awarded to those who complete the course satisfactorily. The semester opened September fifteenth with fifteen students registered in the two year course. Considering the fact that this work is now offered for the first time in history of the college, this is considered to be a good showing. This work will undoubtedly prove more popular as it is better known.

The fourth feature of the work of the department consists in providing lectures along engineering lines for organizations of workmen and manufacturers and for others who may be interested. Lecturers will be furnished who will be able to handle the live subjects of the day along engineering lines. Choosing a vocation, modern safety appliances and devices, gas power engineering, operation of traction engines, steam power plant operation, the industries of Iowa, together with subjects of more popular interest having to do with engineering are some of the lectures which will be prepared. In this connection a winter short course will be held at the college when instruction will be given in cement and clay working, road making, agricultural engineering, power plant operation and other subjects by means of lectures and class room instruction.

The success of any undertaking depends largely on the vision, ability and initiative of the persons in charge. The college has

secured Mr. K. G. Smith, formerly in charge of the Milwaukee District of the University Extension Division of the University of Wisconsin to take charge of the work. Mr. Smith is thoroughly familiar with engineering extension work and will insure its success at the Iowa State College. Mr. J. W. Parry, also formerly of the Engineering Extension Division of the University of Wisconsin, is secretary of the department and has charge of the publicity and lecture features of the work. Mr. Parry is experienced in this line and will add much strength to the organization. Mr. R. B. Dale, recently of the College of Applied Science, State University of Iowa, has charge of the work in correspondence instruction. Mr. Dale has had practical experience in the shop and office coupled with experience as teacher. Mr. E. S. Shortess has had considerable experience as school administrator and organizer for the United States government. He is a native of the state of Iowa, and is a man of broad experience along educational lines. Mr. Shortess has charge of the organization work in the field for the department. The staff will be increased from time to time as the growth of the work demands.

The prospects for the success of this undertaking seem very bright. The work has received encouragement from the manufacturers of the state and the industrial workers are taking an interest in the proposition wherever it has been presented to them.

Highway Engineering in Iowa

BY A. MARSTON

The 35th General Assembly of Iowa placed on the Statute Books the State road legislation which has entirely remodeled Iowa methods of road construction and maintenance in the interests of efficiency and good roads, and which has at a stroke made Highway Engineering in the State very important. In other states the same general tendency is seen, and the present prospect is that Highway Engineering is destined to be of great importance in the immediate future throughout the country.

The new Iowa Road Law included the following main essential features:

1st. All TOWNSHIP road work is restricted entirely to the "township roads," and must be done under a township superintendent. It consists of three main lines,

1st. Regular road dragging.
2d. Other road maintenance and repair work.
3d. Permanent road construction.

All permanent construction of township roads must be in accordance with engineering plans, prepared by the County Engineer and approved by the State Highway Commission.

2d. To the COUNTY is entrusted entire jurisdiction over the "county roads" approximating 15 per cent of the total mileage, and connecting all the principal market places. In addition, the county is to build all culverts and bridges, on both county and township roads. Each county is required to appoint a County Engineer who must make and file definite plans for each culvert and bridge, and who must survey each mile of county roads and make definite plans for improvement thereof. All culvert, bridge, and county road work, other than ordinary maintenance and repairs, including the dragging of the roads, must be in accordance with the Engineer's plans. The Highway Commission is the final authority for passing on the plans for road improvement and for preparation of specifications and standards for the road, culvert and bridge work.

3d. The law creates a STATE HIGHWAY COMMISSION of three men, with headquarters at Iowa State College, Ames, Iowa, which will have general jurisdiction over the execution of all the road laws of the State, and the work of all the road officers. The Highway Commission is required to pass specifically on the location of all county roads, and the plans for the improvement of each mile of county or newly constructed township roads, and to prepare definite, authoritative specifications for all culverts and bridges. The Highway Commission is authorized to employ a force of Engineers to do its work, and to fix their compensations. It also has the duty to terminate the employment of County Engineers whose work is not efficient and satisfactory.

It will be seen that the new Iowa Road Law provides a comprehensive and systematic plan for road maintenance and con-

struction throughout the State, and that in this plan Highway Engineers have been entrusted with a most important part. The law went into effect April 9, 1913, and one of the most difficult and important duties which has confronted the Boards of Supervisors of the State and the Highway Commission during the working season of 1913 has been to find competent Highway Engineers to do the work prescribed

The HIGHWAY COMMISSION has effected a definite organization of its engineering force, has engaged the most competent and promising men it could find for the salaries available, and has been drilling and training these men in the actual Highway Engineering work of the State throughout the season. The engineering force of the Highway Commission is organized into four divisions as follows:

1st. The FIELD ENGINEERING DIVISION. In this division five district engineers have been employed, to each of whom has been assigned approximately 20 counties. A Division Field Engineer is placed over the district engineers.

2d. The DESIGNING ENGINEERING DIVISION, with a Division Designing Engineer at its head, has employed throughout the season a force of 8 to 12 men, and in addition to the work on general standard plans, has prepared plans for individual bridges and culverts amounting to over $1,000,000.

3d. The OFFICE DIVISION, with an Office Engineer at its head, attends to the general co-ordination of the engineering work of the Commission, the correspondence, the accounting and the records. The law requires that a duplicate statement of the cost of construction of each structure shall be filed with the Highway Commission, which makes the accounting a large undertaking.

4th. The EDUCATIONAL DIVISION of the Highway Engineering force has at present one employee. Its work will be developed more extensively in the near future.

5th. A STATE HIGH ENGINEER has been employed by the Highway Commission, and placed in general charge of all its engineering work.

The new Iowa Road Law does not contemplate the direct construction of roads, or culverts, or bridges by the State. The State, through its Highway Commission, simply passes on plans,

prescribes standards, and exercises general supervision and direction over the actual work of road, bridge and culvert construction. The counties and townships are entrusted with the actual execution of the work. Hence the engineering force employed by the counties has an extremely important part in the general plan.

The COUNTY ENGINEERS are selected by the Boards of Supervisors of the several counties. The year's experience has shown that the County Engineer's work is of such magnitude as to require the untiring efforts of thoroughly competent men, and that the County Engineer in each county must be provided with at least one assistant capable of running an instrument and doing creditable drafting. In the actual work of surveying a third helper is necessarily employed, sometimes by the day. In the case of construction of large bridges a separate bridge inspector is employed by the county supervisors, in many cases.

The Boards of Supervisors of Iowa have in some cases found it necessary to revise their first estimates of the class of men required for the office of County Engineer. In a number of cases the men first employed have resigned at the instance of the Board of Supervisors or the Highway Commission, and better qualified men have been employed in their places.

Even competent practicing Civil Engineers in the State underestimated at first, in some cases, the importance and extent of the work of the County Engineer Some Civil Engineers with a general practice undertook the duties of County Engineer in one or more counties as a sort of "side line" to their general practice. In all such instances it has been found necessary to require that the full time of the County Engineer shall be devoted to the county work, and this has made it necessary for such practicing Civil Engineers to give up either their private practice or the county work.

The great and growing importance of Highway Engineering work in Iowa, and in the other States of the Union, has made it essential that the engineering schools shall give much more attention than heretofore along Highway Engineering lines. Iowa State College is just recognizing this necessity by greatly extending and improving its *instruction work in Highway Engineering.*

To take charge of the instruction in Highway Engineering the services of Mr. T. R. Agg have been secured. Before he came to Ames, Professor Agg was employed with the Illinois State Highway Commission, and has had a wide experience in Highway Engineering. Part of the work which he offers at Ames is required of all Civil Engineering and Agricultural Engineering seniors, and part is elective. The elective work has proven so popular that it has been necessary to form additional sections to accommodate the number registered for it. Roughly, it may be said that the Iowa State College is offering about five times more work than formerly in Highway Engineering. In addition to the new courses of instruction in Highway Engineering, the Iowa State College is erecting a new transportation building with extensive laboratory equipment in Railway and Highway lines.

A survey of the general situation in Highway Engineering, both in Iowa and throughout the United States, makes it evident that the time is arrived, or near at hand, when the construction and maintenance of the roads of the country will largely be placed in the hands of trained engineers. The attention of the Profession of Civil Engineering should be directed to this situation, and Civil Engineers should use every effort to give worthy service in the grave duties which will be entrusted to them in this vital matter.

Campus Improvements

A $75,000 transportation building, a mechanical engineering testing laboratory, and a new chemistry building are among the improvements that are being made on the campus.

The legislature was very generous last spring in providing for the rapid growth of the school. These buildings for which allowance was made are being rushed to completion. The mechanical engineering building is nearly finished, and some of the equipment is being installed. The building is located north of the old hydraulics laboratory. It consists of a main part 120'x55', containing offices, instrument rooms, and main engine room; and a wing 55'x45', in which will be placed the boilers and the gas-producer equipment. The coal will be stored in

large steel bins over the boilers. A conveyor for handling coal and ashes will be a part of the equipment.

Some of the machines from the old hydraulics laboratory will be removed to this building, but most of the equipment will be new. One interesting feature of the installation will be a 150 H. P. boiler designed for a working pressure of 250 pounds. It will be equipped with a Jones underfeed automatic stoker. A 125 ft. brick chimney will furnish the draft for the boilers. A neat and rather unique method of conveying the boiler gases to the stack, by means of an underground brick passage, is employed. The building will be ready for use the first of next term. C. E. Heaps of Davenport, Ia., is the contractor.

The transportation building is well under way. The contract calls for it to be finished by the first of February. It really consists of two buildings connected by a corridor. The main building, 150 ft. long by 100 ft. wide, will be three stories in height, and similar in design to the engineering annex. The first floor will be used for instruction in automobile and locomotive testing, while the second and third floors will contain drawing rooms for students in railway engineering. The other building, 43'x120', will be but one story high. It will contain the apparatus for locomotive and automobile testing. All the equipment necessary for the actual running of tests on locomotives and autos will be installed. A permanent housing will be provided in this building for the two locomotices which are the property of the college.

The excavations have been made and the foundations placed for the new chemistry hall. Several carloads of material are being unloaded daily, and construction work is being rushed. The new building, located north of Central Station, will be 240 ft. long by 159 ft. wide, and will be three stories high with basement. It is to be constructed of pressed brick, trimmed with Bedford stone. It will contain more floor space than Central Hall, which is really not surprising when we consider that more than eight hundred students are taking work in chemistry.

The methods of construction used on this building are rather interesting. The concrete for floors and foundation is mixed in a large stationary mixing plant. The bins for sand and crushed rock are built directly over the mixer. The concrete

is mixed wet and is elevated to the top of one of three tall construction towers from which it is distributed by gravity. When one of the towers was about half completed it was blown over, injuring two men who were working on it.

A 225 ft reinforced concrete chimney is being erected at the college power plant. It is fifteen feet in diameter, and the foundation is a solid block of concrete, fifteen feet deep. The stack will be finished about the first of January.

Fifteen thousand square yards of concrete pavement were laid on the campus during the past two summers. The pavement now extends completely around the circle from Agricultural Hall to Central, south to Boone street, and out West street past the gymnasium. A protective skin coating of asphalt, covered with sand, is now being placed over the concrete.

Another building which is being rushed is the hog cholera serum plant, for which the legislature provided last spring. It is a brick building, about 40'x60', located north of the Veterinary Building. It is practically completed at the present time. The men in charge have been manufacturing serum all summer in temporary headquarters. The completion of the new building will greatly increase their facilities.

Generally the entering class in their wisdom are ready promptly to denounce as useless or out of place all non-technical studies; thus the sympathetic co-operation of the students which is such an important element in the efficient teaching required in a full course of study, is not obtained, and the foundation is laid for many regrets to to be experienced in the years after graduation.

—*Humphreys*

THE IOWA ENGINEER

Published Monthly During the College Year by the Students of the Division of Engineering, Iowa State College

VOL. XIV   AMES, IOWA,   OCTOBER, 1913   NO. 1

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EDITORIALS.

This issue begins a new volume of The "Iowa Engineer." The new members of the staff are presenting their first efforts. We realize that the magazine has reached a high class among student engineering publications, and it is with full appreciation of this fact that we are planning to keep it in that class The "Iowa Engineer" has been a true representative of the engineering division, and to keep it so, we ask your support and co-operation.

At the present time we are seeing a great enlargement in the size and scope of the Engineering Division at Ames. In order that the magazine keep pace with this development, several new features will be added. The magazine will be kept a truly engineering journal. Besides its strictly technical articles, matters of

general engineering interest, treated in a more popular way will be published. Because many of our readers are alumni, the more important news of the college will be published. The alumni notes will be continued so that our graduates can keep in close touch with each other. In short, we wish to make the magazine of interest to the ordinary reader and the industrial man or builder, as well as the student or graduate engineer in practice.

We are glad to publish in this issue the article, "Design of Machine Members with Eccentric Loads," by Mr. N. Leerberg, M. E. '11. The mechanical engineer will find this subject of valuable interest. The design of beams subjected to bending is treated from the simpler case up through the various cross-sections to the particular case in question.

Attention is also called here to Mr. Leerberg's success as an engineer. While still a student he was in charge of the M. E. drawing room for a year. At the present time he has charge of all designing for the Ottumwa Iron Works, Ottumwa, Iowa.

With the appropriation made by the last legislature, Industrial Education has begun at Ames this year. We believe this work will become one of the most important departments of the division of engineering. In the articles by Mr. R. B. Dale in this issue, the great benefit to the workingmen of the Iowa mills and factories is well brought out. Since the idea of engineering extension is such a vital one, it will be our policy to keep our readers in touch with the progress of the work

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The American Society's for Testing Materials, Committee on Standard Tests and Specification for Drain Tile, of which Dean A. Marston is chairman, is at present conducting quite an extensive series of tests upon various drain tile at the college. In a later issue the Engineer will publish a report of these valuable tests. This society is of national reputation, having conducted numerous tests upon the materials of construction that have proven of very general use. The present tests will supply a great need by enabling the preparation of standard specification for clay and cement tile.

HOW OUR FACULTY SPENT SUMMER.

M. E. Department.

Prof. W. H. Meeker, head of the M. E. department, spent a most active summer overseeing the construction and arranging various details of the new M. E. laboratory.

Prof. C. C. Major was with the maintenance and operating department of the Western Electric Co., Chicago.

Prof. R. A. Norman assisted by John Hugg worked out a unit cost system on the comparative cost of general locomotive repairs for the C., M. & St. P. R. R. at their Dubuque shops.

Prof. R. H. Porter conducted experimental tests with oils as a fuel for the John Deere Co., Moline, Ill.

Professors M. P. Cleghorn, J. G. Hummell and J. T. Bates enjoyed vacations.

E. E. Department.

Prof. F. A. Robbins worked in the Industrial department of Westinghouse Electric Co.

Prof. F. D. Paine made several improvements in the E. E. laboratory.

Prof. H. C. Bartholomew spent his summer here sweltering in the hot sun, enjoying his vacation.

C. E. Department.

Dean Marston, who became a member of the State Highway Commission under recent law, was fully occupied with these new duties and his previous ones.

Prof. E. E. King was busy to say the least over plans in connection with the new Railway and Transportation building.

Prof. H. C. Ford had charge of the C. E. summer camp at the lakes.

Prof. Evinger devoted his time to consulting engineering work, having opened up an office.

Prof. R. W. Crum spent the summer at Watertown, S. D., assisting the city engineer with the construction of a large job of solid concrete and asphaltic concrete pavement.

Mining Department.

Prof. S. W. Beyers was out over the state an appreciable portion of his time in connection with geological work.

WITH OUR PROFESSOR AUTHORS.

It is with true pride that the Ames Engineers see the adoption of our own Prof. Spinney's text book of Physics by such schools as Harvard and Stanford, which are but two of the thirty-two schools to adopt it. This fitting acknowledgment as to the worth of Prof. Spinney's work meets with extremely popular favor with all who have had the pleasure to know him.

Dr. W. B, Anderson of the Physics department spent the summer preparing his book "A General Physics for Agricultural Students." Realizing the difficulty attending such a task and the need of such a work we hope his efforts meet with deserved approval.

Prof. F. A. Fish, head of the E. E. department, worked through the hot summer preparing the first draft of his book "Principles of Electrical Engineering," mimeograph copies of which the Junior E. E.'s are now using. The reports from them state that it is written in a concise and contrary to some E. E. books, is written in intelligible English.

Prof. J. E. Kirkham's book on "Structures" will soon be a certainty as Prof. Kirkham practically finished the final draft of it this summer, the book now being in the hands of the publishers.

FACULTY CHANGES.

Prof. Jones, a Purdue man, takes Prof. O. H. Hoffman's place in the Physics department, Prof. Hoffman turning to an Ag. Engineer student.

Frank Dragoun, C. E. '10, takes C. Coykendall's place, assistant professor in the C. E. department, Coykendall becoming District engineer under the new Highway Law. Mr. Dragoun was County Engineer at Watertown, S. D., and has had considerable practical experience.

O. A. Olson, M. E. '08, coming from the Western Electric Co. plant, took up his position this fall as Instructor in the Mechanical Engineering Drawing department.

Prof. T. R. Agg, a leader in highway work at the present time, takes a new position in the C. E. department as Professor of Highway Engineering, a course which was added to the present curriculum of Engineering courses this fall.

OUR CAMPFIRE.

During the month of October in 1909 the Engineering faculty at Ames successfully laid the foundation for our annual Engineering campfire.

The campfire consisted in a "coming together" of all the students of the various engineering divisions around a campfire in the North Woods where, besides enjoying basket lunches and roasted wienies, good local vaudeville acts were enacted and enthusiastic talks by our faculty were given.

The campfire was turned over by the faculty to the student engineers for conductance in 1910 and they rose under the responsibility with great credit to themselves. It was at this campfire that the plans were laid for our present Engineering society, the one society for all engineers.

The campfire is our one function where all the engineers pull together, where unity stands first. It should be continued in such a manner not only that this feeling of unity may exist but actually be made stronger.

The campfire coming, as it does, at the beginning of the College year gives the Freshman his first view of an Engineering education. The Engineering talks by our faculty and old students which were in order at our second campfire impressed upon the Freshmen the possibilities of an Engineering education such as could not be accomplished in any other manner.

Each year since 1910 has seen the campfire grow. In place of the green grass for a stage and the light from the glowing campfire for a footlight has come an erected stage with electric footlights. In place of our local vaudeville talent has come expensive though often poor "talent" from the Sullivan & Considine circuit. In place of the upper class now paying 25 cents campfire dues has come the burden of 50 cents dues upon our whole Engineering body. The campfire has grown outwardly but we fear that much of the spirit and effectiveness of the 1910 campfire is gone.

Engineers of 1915-16, it rests upon you to see that the great possibilities of an Engineering campfire are not carelessly or thoughtlessly destroyed.

ALUMNI NOTES.

L. L. Lyford, C. E. '04, who is in the office of chief engineer of the Illinois Central in Chicago, spent a week on the campus the last month.

A. C. Bullen, M. E. '10, and wife spent a few hours on the campus last month on their way to Swink, Colo., where Mr. Bullen has a position with a beet sugar factory.

James A. Buell, C. E. '05, is chief engineer for the United Steel Co. at Canton, Ohio.

F. E. Triggs, M. E. '13, is located at Clarion, Ia., where he is engaged in the plumbing business.

Word has been received that E. L. Evans, M. E. '11, was drowned while in swimming at Campbell's Island, Davenport, Ia., September 10.

D. W. Hoot, E. E. '13, who was with the Ft. D., D. M. & S. Ry. during the summer, is now located with the General Electric Co. at Schenectady, N. Y.

D. H. Kilby, E. E. '13, is employed by a large electrical manufacturing company at St. Louis, Mo.

Joe E. King, E. E. '09, has a position with the Nevada-California Power Company, at Goldfield, Nevada.

Joseph Pickus, C. E. '13, is with the Burrell Engineering and Construction Co. at Detroit, Mich.

Porter Eveland, E. E. '03, is with the Salida Power Co., at Salida, Colo. He was formerly located in Arizona.

H. C. Hunter, H. X. White and Carl Stewart, C. E. '13, are with the American Bridge Co. at Ambridge, Pa.

Harry Allstrand, M. E. '13, is sub-foreman of the C. N. W. Ry. roundhouse at Clinton, Iowa.

Paul Clapp, E. E. '13, is working for the Automatic Electric Company, in Chicago.

C. E. Brown, E. E. '93, is with the Commonwealth Edison Company at 28 N. Market St., Chicago, Ill.

G. C. Peterson, C. E. '05, who has been for several years the general manager of the Cuban Eastern Ry. with headquarters at Guantanamo, Cuba, is now in Wisconsin, recovering from an attack of malaria.

THE IOWA ENGINEER

VOL. XIV. NOVEMBER, 1913 NO. 2.

CONTENTS

PUBLISHED MONTHLY DURING THE
COLLEGE YEAR BY
STUDENTS OF THE DIVISION OF ENGINEERING
IOWA STATE COLLEGE, AMES, IOWA
Annual subsription $100 Single Copies, 15 cents

The Qualities of a Successful Engineer

FOR many years, graduates from the Engineering Division of Iowa State College have been taking equal rank with graduates with other great engineering schools throughout the country. Ames engineers are found in high positions connected with railroad building and operation, manufacturing electric power enterprises, various kinds of structural work, and in connection with great improvements requiring the skill which comes only from thorough training in one of the several branches of engineering.

If it weie possible to take an accurate and detailed census of our engineering graduates, it would be found that they have some characteristic in common. These include first, devotion to their fubject,—and willingness to sacrifice pleasures and even duties to meet their professional calls. Secondly, hard and thorough work,—nothing that is worth while can be expected to come without effort most of those who get good positions, and supposedly with luck, are persons who have studied long and hard and learned to acquire information under difficulties. Third, the successful engineers are men of character,—everyone whether he realizes it or not, is building a life structure, and the successful men are constantly careful that no rotten material finds its way into the wall on which the superstructure must be laid. A fourth quality found in successful engineers is a well fixed habit to continue study and investigation after leaving college. A man of forty should be able to say that he has learned as much in his profession after leaving college as he learnəd in college, and some have learned more. The broad, fundemental principles are given in college, and their application is carried on as far as possible. But new discoveries are being made constantly, and new applications are being brought out, and the engineer who keeps in touch with these developments, as he may easily do through technical literature and engineering societies and contact with other experts, finds himself keeping abreast of his profession.

—*R. A. PEARSON*

New Orleans and Northwestern R. R. 210 Ft. Span East River, Nicholson Miss., Designed and Built by A. M. Blodgett, Contracting Engineer Kansas City, Mo. See page 61

VOL. XIV. NOVEMBER, 1913 NO. 2.

Springfield Sewage Disposal Plant and its Departure from Common Practice†

BY ALEXANDER POTTER*

GENERAL.

The city of Springfield, Mo., is located two hundred and forty miles southwest of St. Louis, among the foothills of the Ozark mountains, 1,400 feet above sea level. During the last decade the growth of the city has been very rapid. The population in 1900 was 23,000 and in 1910 it was 34,000. The present estimate is placed at 46,000. The area of the city is fourteen square miles.

The last two administrations have been progressive and public-spirited to a marked degree. Large sums have been spent on much-needed public improvements; so that where a decade or so ago Springfield was only a sleepy, over-grown town, it is now a hustling and up-to-date city.

The built-up part of the town is sewered and recently sewer extensions have been built into the fast growing outlying dis-

†From the Report of the Twentieth Annual Convention of American Society of Municipal Improvements.

*Consulting Engineer, 50 Church Street, New York.

On account of the small quantity of water flowing in Wilson and Jordan creeks during the greater portion of the year, the treatment of the sewage in settling tanks alone would not give a sufficiently pure effluent to abate the nuisance. Some additional treatment, such as contact beds or intermittent filters, was therefore absolutely necessary. To obtain a head at the southern outlet sufficient to operate a filter would back up the sewage in the main outfall sewer for a distance of at least 3,500 feet. This sewer, which is an egg shaped brick sewer, 28 inches x 42 inches, was not strong enough to withstand any internal hydrostatic pressure without rebuilding. Above its mouth the outlet sewer for a distance of 3,200 feet has a fall of only 4.6 feet; at this point there is a two-foot drop and the grade increases to 4.1 feet per thousand. It was recommended that the treatment plant be built at the point where this change in grade occurs. To obtain at this point the necessary head to operate the plant only 2,000 feet of sewer would be surcharged. For a distance of 1,436 feet, that portion of the length where the hydraulic gradient falls above the natural surface of the ground, the existing egg-shaped brick sewer was replaced with 36-inch reinforced concrete pipe of the Meriwether type, designed to resist this pressure. This reinforced concrete pipe has been found very satisfactory under the head to which it was subjected, viz.: from 3 feet to 10 feet, and the line appears to be practically watertight. The existing sewer below the sewage disposal plant was not rebuilt and is used to convey the effluent from the plant to the outlet.

TYPE OF PLANT RECCOMMENDED.

On account of the limited area available it was deemed advisable to use intermittent filters instead of contact beds. The ordinary type of sprinkling filter could not be used, as such a filter requires a head of at least five feet to operate the nozzles. Such a head could be obtained only by pumping. Mechanical distribution was therefore recommended. The distributor selected is operated with a head of only 12 inches.

Plate 1 shows the general arrangement of the plant as built. It consists of a grit chamber built in duplicate, two settling tanks of the two story type, a sprinkling filter divided into six

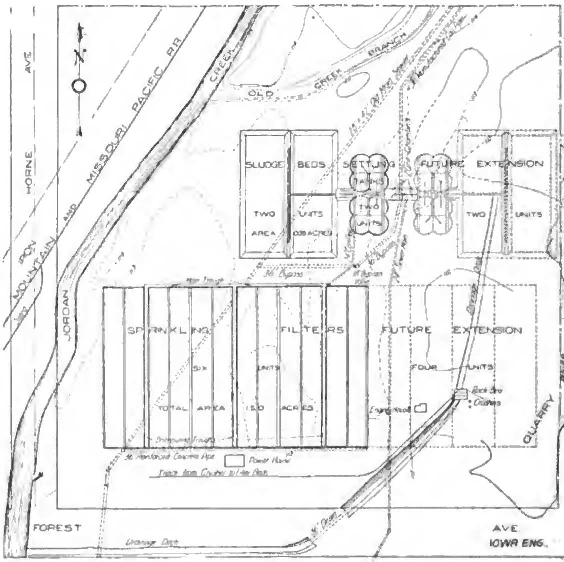


Plate 1. Location Plan of Southern Sewage Disposal Plant

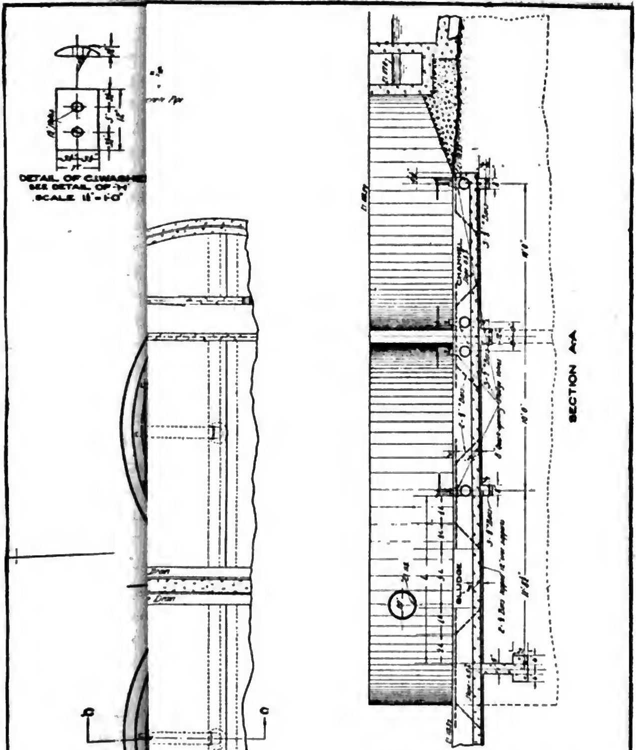
units, each 53 feet 9 inches wide and 200 feet long, a sludge bed 0.35 acre in extent, and a final settling basin of 150,000 gallons capacity, located at the outlet, 3.600 feet from the remainder of the sewage disposal plant.

GRIT CHAMBER.

The grit chamber is constructed in duplicate. The flow in the grit chamber is retarded sufficiently so as to retain only the suspended mineral solids which would interfere with the operation of the settling tanks. Provision is made so that during times of flood the back pressure on the outfall sewer can be readily and quickly relieved, thus scouring out whatever deposits may have formed in the 36-inch reinforced concrete pipe.

SETTLING TANKS.

Type Selected. Concrete, either plain or reinforced, is prac-



SPRINGFIELD MO.

SOUTHERN

SEWAGE DISPOSAL WORKS

PLAN AND DETAILS OF SETTLING BASINS

SCALE ⅛"=1'-0"

114 LIBERTY STREET
NEW YORK CITY

Alexander Potter
CONSULTING ENGINEER

1912

IOWA ENG.

tically the only structural material available for constructing sewage settling tanks of the dimensions required for a large municipality. So far as the writer knows, the circular tank has been used in this country only in constructing the smaller units; for the larger sizes it has been customary to use rectangular construction. The rectangular form under all conditions, and especially when a large portion of the tank is above the surface of the ground, is a more expensive form to build. The Springfield sewage tanks are neither square nor truly circular. Each unit is four-leaf-clover shaped, consisting as it does of four semi-cylindrical segments 26 feet in diameter. This type of construction is peculiarly well fitted not only to resist the water pressure from within, but also the earth pressure from without when the tank is below the ground and empty. The construction features of the tank are clearly shown in Plates 2 and 3. The shell of the semi-circular segments is 12 inches thick, reinforced vertically with ¾-inch bars spaced 3 feet centers and circumferentially with ¾-inch square bars spaced so that the unit stress does not exceed 14,000 lbs. per square inch. The unbalanced tension at the point where the semi-circular segments intersect is taken up by 1¼-inch circular rods embedded in concrete struts—see Detail H of Plate 2.

The steel reinforcement in these ties is designed to resist the tensile forces at the same unit stress as the circumferential reinforcement in the shell. If this is not done, and different stresses are used for the tie rods than are used for the shell, the shell, instead of being subjected to simple tension, will be subjected to bending. The tie rods are fastened to a steel plate 8 inches wide, ⅞-inch thick, bent to a 5-inch radius. By means of double nuts the reinforcement is kept in accurate alignment which insures equal distribution of the tension among the larger number of the tie rods.

Precaution Necessary to Prevent Secondary Stress. The cylindrical segment must be free to expand in all directions. If the expansion is in any way prevented by interior construction, such as the troughs, false bottoms, beams, etc., the shell, instead of being under tension only as contemplated by the designer, will be subjected to heavy bending, often sufficient to

cause the fracture of the structure. To permit of the free expansion of the shell when under internal pressure, all interior construction, except at the intersection of the ties and struts with the shell, is separated from the shell by expansion joints.

Operation of Tank. After passing through the grit chamber, the sewage enters the distributing trough, which is 2 feet wide, and holds, under normal conditions, about 2 feet of liquid. (See Plate 3.) Eight 8-inch circular openings, placed in the sides of the trough near the bottom and on the side next the outer wall, admit the sewage to the settling compartment. At the end of the trough is an additional opening, placed so as to be but half submerged, so that whatever scum may tend to collect in the distributing troughs is carried over into the settling compartments. Each settling compartment has a capacity of 111,000 gallons, which gives an average period of retention of 1.4 hours when the plant is operated at 4,000,000 gallons, its capacity. The flow in the settling compartment is parallel to the direction of the slot. To prevent eddies and other disturbances from being set up in the settling compartment which might interfere with the settling efficiency, the liquid is admitted to the settling compartment in a direction opposite to that which it must take in passing through the compartment. The clarified sewage leaves the settling compartment over eight 15-inch weirs discharging into the collecting trough.

Concrete Struts not Objectionable. The presence of the concrete struts in the settling compartment does not in any way interfere with the efficiency of the tank. Where necessary, they can be capped with wedge-shaped pieces of concrete having slopes of at least 45 degrees.

In that circular segmental area between the distributing trough and the shell of the tank, all of the floating matter is collected and forms a very heavy scum, requiring slight attention from the operator.

Vertical Circulation Used to Increase the Settling Efficiency of the Tanks. To increase the settling efficiency of tanks of the type described, the writer uses vertical circulation. The amount of sewage thus circulated is very small and does not exceed two per cent of the total amount of the sewage treated.

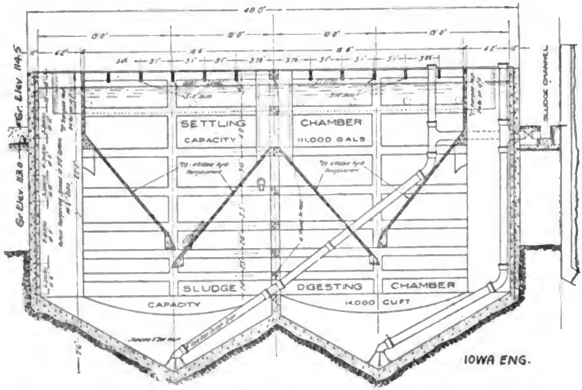


Plate 3A. Detail Section of Main Settling Tank Section on C-C

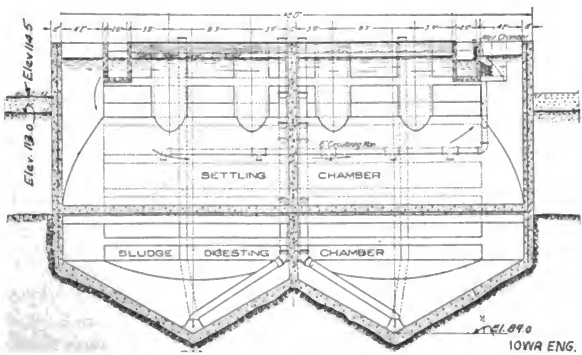


Plate 3B. Detail Section of Main Settling Tank Section on B-B

To accomplish the vertical circulation mentioned, a 6-inch cast iron main with four 4-inch circular openings is laid in the digesting chamber of each tank, about 6 feet above the slot. (See Plates 2 and 3.) This circulating main terminates in a

small chamber located in the segment between the collecting trough and the shell, which chamber has an adjustable weir to control the flow from the digesting chamber into the collecting trough. In the Springfield plant the liquid thus drawn off is mixed with the effluent from the settling compartment and the resultant mixture is treated on the sprinkling filters. In other plants that the writer has built, the liquid drawn off from the digesting chambers is returned to the distributing troughs. Circulation such as that used in Springfield is especially of value when the sewage to be treated reaches the plant in a more or less septic condition. The Springfield plant has not been in operation long enough to determine the exact value of the circulation system.

Sludge Digesting Chamber. The suspended organic and mineral matter which settles out of the sewage in the settling compartment, slides down the inclined plane through the 8-inch slots located in the bottom of the wedge-shaped settling compartments into the sludge digesting chamber. The sludge digesting chamber has a capacity of 105,000 gallons below the opening. The bottom of this compartment is formed by four cone-shaped depressions in which the decomposed sludge ultimately collects. To draw off the sludge, 8-inch cast iron sludge pipes extend down into these cone-shaped depressions, the sides of which slope at an angle of 30 degrees. The lower ends of these pipes terminate in bell-mouths supported on spiders. The sludge pipes are carried up inside of the tank to the top, giving ready access for cleaning. The sludge outlets, of which there are four for each unit, discharge under a 5-foot head into a reinforced concrete trough which conveys the sludge to the drying beds. The open channel used for conveying the sludge is preferable to the closed pipes generally used. In an open channel the sludge drawn off is at all times visible to the operator, and therefore the character of the sludge drawn off can be controlled far better than when a closed sludge conveyor is used. There is positively no odor during the operation of the sludge valves, either in the trough or upon the sludge beds.

Economy of Construction. The Springfield tanks have been found to be very economical in construction. Concrete and

steel are used under ideal conditions to resist the pressures to which the tank is subjected. From the contractor's standpoint also the cost of constructing the tank is not excessive. To construct the conical bottoms of the digesting chamber a vertical pipe 2 inches in diameter was placed in the center of each cone and firmly braced. From this pipe was suspended a wooden triangle adjusted at such an elevation that the hypothenuse described the interior surface of the cone when rotated about the pipe. The concrete was mixed rather dry and placed in 4-inch layers and tamped as much as it would stand, the last layer being carefully brought to a true line by the swinging template. A ½-inch coating of 1 to 2 mortar was applied to the interior of the cones to give them a smooth surface.

To construct the outside shell of the settling tank the constructor used wooden forms made in 5-foot sections 2 feet high. A complete set of inside and outside forms was built extending entirely around one tank, and a complete ring 2 feet high was poured at one time. The following day the sectional forms were raised 2 feet and wired in place at the new point. No trouble was found in shifting the forms and holding the walls plumb and true to line. The false bottoms of the settling compartments were built of No. 28—4-rib hyrib plastered with mortar to a thickness of 2½ inches. The circular ventilators also were built of hyrib and plastered with cement mortar, no other forms than templates being used.

INTERMITTENT FILTERS.

To reduce the loss of head to a minimum power driven mechanical distributors are used to distribute the sewage on the filters. These distributors were manufactured by the Ham Baker Company of London, England. They are designed to distribute the sewage upon the beds with a loss of head, not to exceed 12 inches when the liquid is applied at the maximum rate of 720 gallons per square yard per day. Fig. I shows a view of one of these distributors. Each distributor is supported on three rails, spaced 25 feet on centers. The length of the travel is 200 feet.

The effluent from the settling tanks is conveyed by a 24-inch

reinforced concrete pipe to a main distributing trough located at the north end of the filters. The lateral distributing troughs which supply the traveling distributors are fed by 3-foot weirs from the main distributor. The object of these weirs is to insure a uniform distribution of the liquid to the distributors. The depth of the filtering material ranges from 6 feet, 6 inches in the center to 6 feet at the sides. The underdrains were not

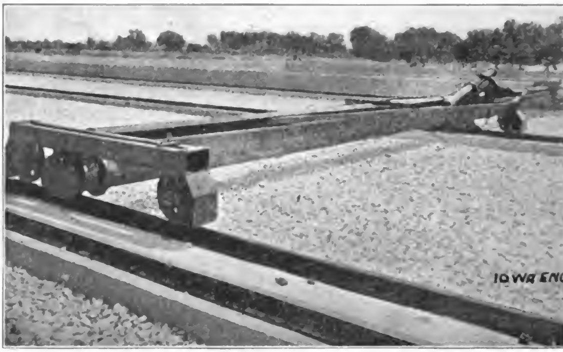


Fig. 1.—Power-Driven Travelling Distributor

built as in the original plan. Instead of using 6-inch channel tile, the contractor was given permission to construct 6-inch semi-circular channels in the concrete floor and cover them with vitrified tile slabs. The main collectors are semi-circular in shape, 18 inches in diameter and of variable depth, the distance between them being about 25 feet. The rails on which the distributors travel are supported by concrete girders carried by piers spaced 12 feet, 5¼-inch centers. The area covered by each distributor is enclosed by an 8-inch concrete wall. The winter temperature of Springfield is sometimes so low that it may be questionable as to whether the traveling distributors can be successfully operated in extreme weather. Should the traveling distributors go out of commission or any of them break down, it is possible to utilize the filters or any unit there-

of as a contact bed to be operated by hand, suitable gates being provided for this purpose.

Operation of Distributors. Extending down the center of the filters between two of the traveling distributors is a 3-foot rectangular conduit in which the normal depth of sewage is 16 inches. A cast iron siphon, 24 inches long and 8 inches in width, conveys the liquid from this trough to the distributor. This siphon is provided with a gunmetal air cock and brass air exhaust pump for starting the flow. The siphon discharges into the feed tubes, of which there are two. These feed tubes are made of wrought iron 3/16-inch thick and have an external diameter of 7⅜ inches. The feed tubes are supported at each end and at the center by a cast iron carriage braced together by rolled steel beams so as to form a rigid structure. In each feed tube just above the center are located ⅝ x 4-inch orifices, spaced about 15 inches lengthwise. The even distribution on to the beds is accomplished by a distributing tube 2½ inches in diameter, located between the feed tubes. This distributing tube is built in sections and can be raised or lowered as required to control the flow of sewage upon the beds. The feed tubes are protected with galvanized sheet iron covers provided with hinged access doors. The protection extends to within one inch of the surface of the bed in order to conserve the heat in the sewage as much as possible, especially during the cold weather. It also acts as a preventative of flies. A space is provided between the two channels supporting the feed tubes, which during the cold weather is to be filled with moss, leaves or other insulating material.

Each pair of distributors is operated by an endless wire cable. All three sets of cables are driven by one six horse-power Otto gasoline engine, which gives the distributors a speed of 38 feet per minute. The change in direction of the distributors is accomplished by means of the reversing lever.

The distributors have realized every expectation. Less than two horse-power is required to drive all six distributors. The writer believes that the distribution of the liquid over the bed is more uniform than can be obtained by the methods now in use in this country. The more uniformly the liquid is distributed upon a filter, the greater the quantity of sewage that

can be applied to the filter to obtain the same degree of purification; or, with a given quantity of sewage, the more uniform the distribution, the greater the purification.

First Used in Springfield. To the knowledge of the writer this is the first time that power-driven traveling distributors have been used in this country. The range of temperature at Springfield makes this installation an important one as indicating possible limitations of service in extreme winter weather without covering the filters.

FINAL TREATMENT OF FILTER EFFLUENT.

The existing sewer conveys the filter effluent to the final settling basin located near the mouth of the existing sewer. This final settling basin is 150 feet long and 50 feet wide and has a capacity of 150,000 gallons. A reinforced concrete channel admits the sewage to the basin at the upper end and at the lower end a similar channel conveys the settled liquid through a short length of the existing sewer to the outlet in Wilson creek. It has not been deemed necessary to sterilize the effluent.

SLUDGE DISPOSAL.

The sludge which is drawn off from the main settling tanks is conveyed by a concrete trough laid to a grade to 5/10 of 1 per cent to the sludge beds. The sludge bed, which takes in an area of .35 of an acre, is divided by wooden partitions into twelve units, each unit being 25 feet wide and 50 feet long. Each sludge bed is underdrained with graded gravel 18 inches deep at the center and 12 inches deep at the sides. Down the center of each unit extends a 6-inch vitrified underdrain laid with open joints. The surface of the gravel is covered with a thin course of mortar sand to prevent the sludge from working its way into the gravel. The bed is given a slope of 1 inch in 10 feet away from the sludge inlet to assist in the distribution of the sludge over the entire bed.

DISPOSAL PLANT FOR NORTHERN DISTRICT.

The sewage disposal plant for the northern district is located near Doling Park. It has a capacity of 500,000 gallons in twenty-four hours and, with the exception of the distribution of the sewage over the filter, is in all respects similar to the

plant just described. Instead of mechanical distribution, nozzles are used to distribute the sewage over the beds.

Both plants were efficiently constructed by J. C. & E. T. Likes, contractors, of Des Moines, Iowa, the south plant under very adverse conditions. The south plant was constructed for the sum of \$76,063, and the north plant for the sum of \$14,795, thus keeping well within the appropriation of \$100,000.

The writer's principal assistant, Mr. A. H. Beyer, was in charge of the development of the details. Mr. H. C. Atwater was resident engineer during the entire construction of the plants.

Aids To Navigation--Panama Canal

R. Z. KIRPATRICK B. C. E. '07.

While the engineering literature is teeming with printed matter on the various phases of the Panama canal construction, little is said about the various structures aiding in a safe passage of a ship through the channel. It is believed there is a more elaborate system of range lights, buoys and beacons there than on any other similar project in the world. The general scheme of thorough, permanent construction has been carried out on this part of the work, in that only reinforced concrete and non-corrosive metal structures were used.

The channel varies from 300 to 1,000 feet in width, being narrowest in Culebra cut, and widest through Lake Gatun. The sea level channels on the Atlantic and Pacific sides are mostly 500 feet wide. The general scheme is two range lights in concrete towers, usually on the bank, at the end of all long tangents of the canal. These lights are 125 feet to starboard side of the axis of the canal—except at the entrances where they are on the axis lines produced—making it 250 feet center to center of ships passing each other. This permits each pilot to continue on his course uninterrupted. The channel is marked by buoys, starboard and port sides, in

Front Lighting Tower, Range 1-2, Gatun Lake Section, on South Middle Approch Wall of Gatun Locks

the lake and sea level sections, and by beacons in the Culebra cut section. These beacons and buoys are spaced about one mile apart, coming in pairs each opposite one another. In the cut and four of the shorter lake tangents beacons and buoys only are used, the banks being either too high or dis-

tances too short to keep range lights from being confusing. In all there are to be ninety-one beacons, fifty-seven gas buoys, seventy-six spar buoys, seven nun buoys, and a light and fog signal on the breakwater at the Atlantic entrance.

Over 2,000 acres of jungle were cleared to give unrestricted view of the range lights. Considering the dense and rapid tropical growth this will always be a considerable care and expense to maintain.

The lights are electric wherever near the Isthmian transmission lines, and acetylene gas elsewhere. The tower construction in the lake region was delayed until such a time as the lake level permitted floating the material to the vicinity of the sites, which were invariably in lonely, isolated localities. The cut beacons will be installed after the slides are more nearly quiescent than at present. It may be necessary to use temporary lighting in a few localities at first, in this section. The range lights will have intermittent flashes of different frequencies, with a white color. Reflectors make them visible in the proper direction only.

The construction of forward tower, range 3-4, Pacific division, presented some interesting problems to the field forces. It is situated in Panama bay which has a range of tide of about twenty feet. At low tide, the site was a sand bank, two feet above the water line. Piles were driven, at high tide with a marine driver, they being later capped with a concrete foundation, reinforced with old French rails, at low tide. Meanwhile a reinforced concrete caisson, twenty-four square and eight feet high, divided into four compartments, having twelve inch walls, was erected on the Balboa shipways, one-half a mile from the tower site. The entrance to the shipways were good for but a six-foot draft at high tide, hence it was not feasible to build the caisson to its full fifteen-foot elevation, before launching. When successfully launched, it was carefully towed to the site and sunk to position by opening the gate valves in the walls, admitting water. This was done at high tide, in a severe surge, and was accomplished only after the third attempt, by carefully adjusting the hawsers simultaneously. As all hands were in small boats, bounding about in the surf, a considerable element of luck,

as well as skill, was necessary for accomplishment. The caisson was then weighted down with stone, completed, and tower erected with no more difficulty than usual to doing concrete work on a barge, bounding about in the sea.

The towers were molded in steel forms, which were designed to four-foot heights and of sizes such that could be handled by two laborers. The forms for the octagonal base were first set up and filled with concrete, after which the bottom ring of the conical portion of the tower was set up and filled, this set of forms was then surmounted by another and filled, the process being continued so up to the belt course of the watch room. After the concrete in the lower ring set, the forms were stripped, being used in the upper courses, and so continued, thus requiring but two sets of forms. Forms were made in segmental sections or staves, and the proper taper given by omitting a section, or by substituting a narrower wooden stave, as the form progressed to its higher position. All work was carried on on a scaffold inside the tower, the tower going up at the rate of four feet a day. Wooden forms were put inside the outer and inner steel forms for coring out openings for doors and windows. These openings were later trimmed with concrete architrave moldings, sills and lintels. The only metal exposed consisted of gallery railings, lantern door, and sash and ventilators, all made of rust-resisting iron and bronze. The candlepower of the range lights varies from 2,500 to 15,000 candlepower, the more powerful being at the canal entrances. Beacons and gas buoys have about 950 candlepower.

The gas buoys are cylindrical floating tanks, surmounted by a steel frame carrying the lens. The body has a counterweight to maintain the lantern frame in an upright position. The buoys are moored along the channel by heavy chains and a concrete sinker, and are expected to burn from six to twelve months on one charge.

The Application of Power to Agriculture

PROF. J. B. DAVIDSON*

A prominent rural economist, a few months ago, in lecturing to an audience of Iowa teachers and students, made the statement that mechanical power would never, as long as the world continued, be able to compete with the horse as a source of power for agricultural purposes. No lengthy discussion was entered into, and no reasons were given for holding to such an opinion other than the fact that the horse was the most efficient motor in existence. A bare statement in regard to efficiency does not mean much,—yet the statement seems to be definite enough to indicate that this economist, after such study as he has given the matter, has reached, without much reservation, the conclusion that the horse is to furnish the principal source of power for agriculture.

No one need be alarmed especially if this is to prove true. If the horse is to furnish the power for agriculture for all time, that fact should not interfere with progress. We are inclined, however, to question the reliability of such a statement and cannot see how any one could form such an opinion after observing the tendencies of the time.

Mechanical power, or power from other sources than the animal, is finding rapid and general introduction into agriculture. Progress during the past ten years has been rapid, and there seems to be no inclination to check the development. It is not difficult to relate industrial development to the general use of power. This is true not only in manufacture, but also in agriculture. When the farmer tilled the soil unaided by any other source of power than his own physical resources, his capacity and ability for work was much limited. It was only when man began to use the animal to supplement his own energy that agriculture took a decided step forward. It was found in production of power that man could not compete with the horse. For plowing and general agricultural

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work, no one dares to attempt to prove that man is able to compete with the horse. Now the general substitution of mechanical power for animal is simply another step in the same direction.

There are two reasons why we may expect mechanical power to be substituted for animal power: First, the cost of power from fuel is cheaper than that from feed stuff. Second, the individual worker can utilize more power from mechanical source than he can from animal source.

Considering the first point, the fuel for an oil engine should not exceed in cost, for the conditions which prevail in the middle west, more than 2 cents per horsepower hour. If allowance be made for other items of cost, such as interest on investment, depreciation, etc., it is not likely that the cost per horsepower hour, under usual farm conditions, should exceed 5 or 6 cents per horsepower hour. This is true of steam and internal combustion motors. A careful investigation of the cost of horse labor in Minnesota and New York states indicates that the cost per hour of labor varies from 8 to 15 cents per hour. This would seem to be contrary to the statement of the prominent economist which prefaced this article.

It is perhaps true that the thermal efficiency of the horse, while working, does exceed that of the average mechanical motor, but energy in the form of feed stuff, hay and oats for instance, costs much more than the energy in the form of gasoline, kerosene or coal. Then there is another important factor which must be considered, namely, the horse or animal must be maintained by feed stuff while not at work. The motor may depreciate, but requires no fuel while idle.

Taking up the second point for consideration, it is found that the social standing of man in industry has been raised in the proportion to the amount of power used. Machine shop practice of the modern day requires that the shop man use a large amount of power. It is also recognized that the output or capacity of the worker is in a direct proportion to the amount of power used. The output is increased by speeding up the machine, and requiring it to do heavier work. The same sort of development has taken place in agriculture. We

have passed consecutively through the age of one, two-horse farming, and are now in what may be called the age of four-horse farming. The modern farmer who makes the best of his opportunity drives a four-horse team in the field. There is a desire to still continue this increase of power, seeking increased capacity or production. There is a limit, however, to the number of horses which may be managed successfully. A six-horse team, for instance, is a cumbrous and unwieldy source of power. It is here that the mechanical motor offers another important advantage. It is possible for one man to control as easily a motor of thirty to sixty horsepower as one of four. The increase of power per worker reduces labor cost, or by increasing the capacity of the man increases his wage rate.

It is true that the modern tractor has certain limitations. The writer is inclined to think that this is due in part to the fact that the tractor has been introduced as a substitute for the horse. When some of the customs and methods, which prevail in connection with the use of animal power, are done away with, mechanical power will come into more general use. Consider the matter of plowing for instance. There was only one way in which the horse could be used for tilling the soil. It was necessary to devise some implement, as the plow which which could be drawn through the soil as the horse walked forward. The horse, in other words, was not able to develop power except by drawing the load after him as he walked. The possible exception to this is the treadmill, the limitations of which are generally recognized. When mechanical power was offered as a substitute for animal power, a tractor was made to be attached to the horse drawn implement and which would draw it as it traveled forward. In order that the tractor might have proper adhesion to the surface of the ground, it was made heavy. In making the tractor heavy, it required a large proportion of its own power to propel itself. It was found that the larger tractors were more economical and more successful in competing with animal power. To utilize these heavy tractors, special heavy implements were designed and used. This resulted in a very low efficiency on the part of the tractor. In many cases it ran as low as thirty per cent.

It is to be seen at once that the low efficiency now prevailing offers a splendid opportunity for progress and development.

Again, the modern plow is not a very satisfactory implement. It does not pulverize the ground as thoroughly as desired, it does not mix the soil and cultivate to the depth generally desired, and lastly such vegetable or organic matter as may be found on the surface is placed in a layer at the bottom of the furrow. It is generally conceded by all that it would be better if this vegetable matter, or plant growth, be thoroughly mixed through the soil. It would thus seem

A new tilling machine which perhaps represents the beginning of a revolution in character of farm machinery.

that the future offers a splendid opportunity for a machine which will overcome the shortcomings of the plow, the implement designed especially for the horse, and at the same time enable a larger proportion of the power developed by a mechanical motor to be utilized in doing useful work. Not only is this true of the fundamental operation of tilling and plowing, but it is also true of the operation involved in the inter-tillage of crops. There is no reason why a mechanical motor could not be utilized in connection with properly designed tools to thoroughly till and cultivate the ground between inter-tilled crops. This is not true at the present

time of implements which must do their work quickly as they are drawn along by horses. The modern inventor is not entirely aloof to these ideas.

The accompanying illustration shows a tilling machine which is being tried out in this country. A drum or cylinder fitted with spikes lifts a layer of soil high enough so when released by scrapers it falls in a revolving beater and is thoroughly pulverized. The spikes are arranged so as to have an involute curvature so that they pierce the soil easily on the front side of the rolling drum, but have a lifting action of the rear side.

It is not possible now to prophesy what development is to come out of all this, but certainly there appears to be splendid opportunity to entirely revolutionize our methods of tillage. Furthermore, it would seem conclusive that a general application of mechanical power to agriculture will not come about until there is a revolution in the character of our farm machinery.

The Use of the Slide Rule in Engineeing Calculations

PROF. H. C. BARTHOLOMEW*

The slide rule is adapted to engineering calculations which must be accurate to a given per cent, the degree of accuracy obtainable being dependent on the length of the rule and the precision with which it is graduated, the number of settings involved and the skill of the operator. It is the object of this article to explain the reasons why the slide rule is particularly adapted to the calculations mentioned and to point out the precautions which should be observed in order to obtain accurate results.

The slide rule makes use of logarithms; for example, the operation of multiplying two numbers together on the rule is based on the fact that

$$\log (a \times b) = \log a + \log b$$

that is, in order to multiply two numbers together by the aid of logarithms, we add the logarithms of the numbers and find the quantity corresponding to the sum. This may be done by the use of a table of logarithms or it may be performed graphically by means of a slide rule.

The rule and the slide are graduated to a logarithmic scale in the following way:

The log of 2. is .301
The log of 3. is .477
The log of 4. is .602
Etc.

Assuming the rule to be divided into 1,000 equal imaginary divisions, 2 is located by the dividing engine at the 301st division, 3 at the 477th division, 4 at the 602nd division, etc. Suppose it is required to multiply 12 by 13. The end of the slide is set opposite 12 on the rule and the result, 156, is read opposite 13 on the slide. Since the log of 12 is .079

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(neglecting the characteristic which serves only to locate the decimal point) 12 will be located at the 79th division of the imaginary scale of 1,000 equal parts and similarly, 13 will be found at the 114th division. It will be seen from Fig. 1 that the setting described adds these logarithms graphically and that 13 on the slide will be at the 193d division of the scale of equal parts on the rule; also that this sum corresponds to the log of the result, 156.

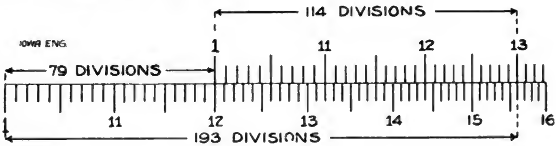


Fig. 1.

In the same way, the division of two numbers depends on the subtraction of the logarithms and the extraction of square root on the principle that the logarithm of the square root of any number equals one-half the logarithm of that number.

That the slide rule is particularly adapted to engineering calculations which must be accurate to a given per cent may be shown as follows:

Let a=any number representing a correct setting.

Let b=the number representing the actual setting and differing form a by any small per cent.

Let k=per cent (expressed as a whole number) by which b is larger or smaller than a.

Then the difference between the logarithms of a and b

$$=\log b-\log a$$

$$=\log\left(a\pm\frac{ka}{100}\right)-\log a$$

Assuming for convenience that b is larger than a, the difference

$$=\log \frac{a+\frac{ka}{100}}{a}$$

$$=\log \left(1+\frac{k}{100}\right)$$

which is a constant for a given value of k and is independent of the value of a. The meaning of the last equation is that the actual difference between a and b in divisions of our original uniformly divided scale is constant for a given per cent difference between a and b and is independent of the value of a.

For example, suppose k is one-fourth of one per cent.

Substituting this value in the last equation, the difference between the logarithms of a and b

$$=\log (1+.0025)$$
$$=\log 1.0025$$
$$=.00108$$

or about one division of our scale of 1,000 equal parts. Assuming that the error in any setting will be about one of these uniform divisions (the length of one of these divisions

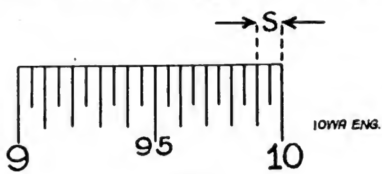


Fig. 2.

is one-half the smallest division of the log scale on the reverse side of the slide of an ordinary ten inch rule), the setting will be in error by one-fourth of one per cent and this will be true for any part of the scale. Theoretically, therefore, the rule may be read to the same per cent accuracy at any point. In the foregoing, this proposition has been proven mathematically. In order to explain the way in which settings

should be made to obtain the same per cent accuracy at all parts of the scale, several special cases will be illustrated.

Referring to Fig 2, which illustrates the upper end of a ten inch rule, the maximum error which would be made in a setting within the space S is one-tenth the distance S. For example, an indicated result of 997 might be read 996 or 998.

Referring to Fig. 3, which illustrates the lower end of a ten inch rule, the maximum error which would be made in

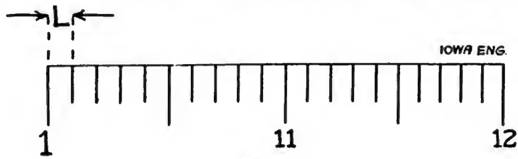


Fig 3.

a setting within the space L is one-tenth the distance L. For example, an indicated result of 1007 might be read 1006 or 1008.

Referring to Fig. 4, which illustrates an intermediate part of the rule, the maximum error which would be made in a

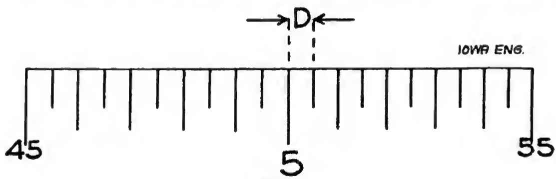


Fig. 4.

setting within the space D is one-tenth the distance D. For example, an indicated result of 5020 might be read 5015 or 5025.

In all three of these cases the per cent error is the same, one-tenth of one per cent. Also since the distances S, L and D are nearly exactly the same, it will be seen that the rule can be read to the same per cent accuracy at any of these three points which agrees with the mathematical proof for the general case. According to the mathematical proof it is

therefore possible to make a single setting on the ten inch rule at any point to this same degree of accuracy, one-tenth of one per cent. Practically, however, it will be found to be somewhat easier to reach this degree of precision at the three points selected for illustration than at some other parts of the scale.

The question is often asked: "How many figures should be read on the slide rule?" This question is answered by the three examples given and it should be carefully noted that they show that if each single setting is to be made to within one-tenth of one per cent, it is just as essential to read accurately the fourth figure in a setting near the left hand end of the scale as it is to read accurately the third figure in a setting near the right hand end of the scale; also that if a result is in doubt between say 5010 and 5020 it should be put down as 5015.

As has been previously stated, the degree of accuracy obtainable will depend partly on the number of settings involved. In general, where the results are obtained by straight multiplication and division, it should be possible to work with an ordinary ten inch rule to within one-quarter of one per cent unless a large number of settings are necessary, and this is in general close enough for those classes of engineering problems which do not require an exact answer.

Uses of Exhaust Steam at Bettendorf Axle Company

C. F. BIELENBERG B. S. E. E. '09.

The Bettendorf Axle company of Bettendorf, Iowa, takes advantage of the considerable supply of exhaust steam for (1) feed water heating, (2) "direct, and indirect" heating, and (3) low pressure turbine electrical power.

The exhaust steam has its source from the following machines:

Hydraulic—

F. M. fire pump, 18"&18"x10"&10"x12".

Crane 350 lb. fly wheel pump. 16"&34"x5"&5"x16".

L. D. S. 350 lb pump, 16"&25"x9"&9"x18".

Worth 1,000 lb. pump. 14"&24½"x3½"&3½"x18".

L. D. S. 1,000 lb. fly wheel pump, 19"&24"&24"x4⅞"&4⅞"&4⅞"x24".

Worth 3,000 lb. pump, 14"&20"x2½"&2½"x15".

Air—

Franklin air compressor, 12"&21"x19"&11"x14".

Ing. Rand air compressor, 12"&21"x18"&11"x16".

Ing. Rand air compressor, 20"&30"x28"&17"x24".

Ing. Rand air compressor. 22"&34"x20"&32"x30".

Electrical—

Ide 100 k.w., 11"&18"x14".

Ide 100 k.w., 13"&20"x14".

West. Parsons 300 k.w. high pressure turbine.

(G. E. Curtis 500 k.w. low pressure turbine receives exhaust steam.)

Miscellaneous—

Worth dry vacuum pump. 8"x14"x12".

50 h.p. DeLaval turbine driver cent. pump.

Epp. Carp. feed water pump, 12"&12"x7"&7"x12".

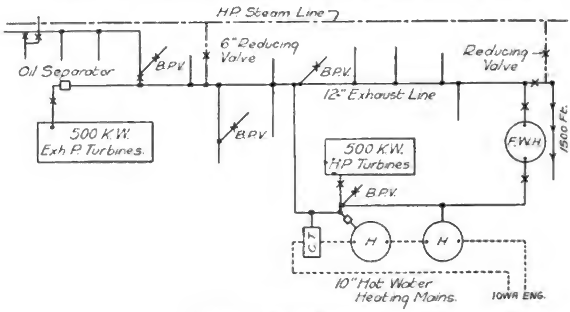
A number of smaller pumps.

From the above it will be seen that there are some duplicate units. Of course, it seldom happens that all of these machines are operating simultaneously. On the other hand

though, it may happen that all the hydraulic pumps stop, and the compressed air output be low at some instant when the electrical output demand from the exhaust pressure 500 k.w. turbine be a maximum; that is to say, the time of maximum hydraulic and air output (or therefore maximum exhaust steam), and time of greatest electrical output are generally more or less out of time phase.

That the low pressure turbine, heaters, etc., may have steam when the exhaust supply is low, a 6" reducing valve is used to maintain the proper pressure (17 to 18 lbs. absolute) in the exhaust main from the 140 lb. live steam header.

On the other hand, if the exhaust steam is more than suffi-



Plan of Exhaust Piping Layout

cient to supply the low pressure system, it goes to atmosphere through four back pressure valves located along the 12" exhaust main.

Originally the circulating pump for the low pressure turbine condensing apparatus was operated by a high pressure turbine, while at nearly all times exhaust steam was going to the atmosphere. Also, this same small turbine was a source of considerable bearing trouble. An electric motor was substituted, therefore. This change meant less exhaust steam wasted to atmosphere; and has demonstrated better economy in fuel consumption, and fewer shutdowns.

The hot well pump for the low pressure 500 k.w. turbine

is motor driven, while the vacuum pump for the same is steam driven. Electric power for starting the condensing apparatus is available from the two 100 k.w. units. (The 50 h.p. DeLaval circulating turbine noted in the machine equipment list is not part of the above condensing outfit, but has its use for circulating hot water for heating purposes.)

The accompanying sketch will give a general idea of the exhaust piping arrangement. It will be seen that the steam received from the various above named machines may be taken by the low pressure turbine; 2,000 h.p. feed water heater "F. W. H.," water heaters "H," and 4" line to building 1,500 feet away. In all cases oil is first removed.

The high pressure turbine pump "C. T." circulates hot water through the erection shop, 1,400 feet by 250 feet, after being brought up to a temperature of about 180° F. by heaters "H-H."

The feed water heater can draw its steam or heat from the 12" main, or from the 300 k. w. high pressure unit. Steam may pass through either way and be relieved of oil and moisture.

A 4" exhaust line leads to a paint and oil house 1,500 feet from the power house for heating. An electric motor driven vacuum pump is used at the lower end to insure plenty of steam. At the power station a reducing valve and check are placed in the line—the check to prevent steam from the reducing valve to enter the 12" main.

The shut off and back pressure valves are so arranged that enough machines may discharge to atmosphere to allow exhaust line repairs

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EDITORIALS

Special attention is called to the article, "Springfield Sewage Disposal Plant, and Its Departure from Common Practice." in this issue by Mr. Alexander Potter, consulting engineer, of New York City. The system is one of unusual design and will be of great interest to engineers doing sewage disposal work. Among the difficulties overcome in designing this plant was the division of the district by a ridge which made two separate treating plants necessary and the small gradients of the outlets. A mechanical sprinkling device, using a head of only twelve inches was designed to replace the ordinary sprinklers which require heads of at least five

feet. The clover leaf shape of the settling basins is another feature of the design.

There is one part of the construction of the Panama canal which perhaps has not received as much notice as other parts, and that is the means of directing the navigation through the channel. A very perfect system of signals, consisting of lights and buoys, has been planned and constructed, which will mark the courses of ships going in either direction. There will be no interruption of passage day or night, or in seasons of fog. The lines of travel are so marked that there will be ample room for ships to pass in any part of the channel. In this issue we are publishing a description of the lighting and buoying system which is of special interest.

Motive power has received a wide application in the field of agriculture during recent years. This is probably due largely to the advent of the gas tractor, which has so largely increased the capacity of a man for work. In the article, "The Application of Power to Agriculture," the author has shown clearly the superiority of tractor plowing over horse plowing on the score of increased efficiency as well as greater economy. While the tractor offers increased advantages at a lower cost, it is not the final solution of the great problem of proper soil tillage. Too small a percentage of the power consumed by the tractor is available for turning the soil. Here, then, is open to the inventor a splendid opportunity of developing a tilling machine that combines greater efficiency with more ideal results.

Engineers in general realize the value of the slide rule as a great conserver of time and energy in connection with their calculations. However, the degree to which its use is applicable is dependent upon the skill of the operator, which comes largely with practice. An engineer may be judged in a measure by his use of the slide rule. Our younger readers will find the foregoing article of considerable value as it shows the adaptability of the slide rule to engineering calculations, giving the necessary precaution to obtain reliable results.

It is with true pride that we show in the frontispiece a work of a noted alumnus, A. M. Blodgett, President of the A. M. Blodgett Cons. Co., Kansas City, Mo. Mr. Blodgett ranks among the greatest construction engineers of the country.

One of his most difficult undertakings was the driving of a water works tunnel under the Kaw River some 60 feet below the stream bed, mainly through shale rocks and granite boulders.

The largest piece of work done by Mr. Blodgett is the great Galveston Causeway, a contract amounting to a million and a half dollars. It is of reinforced concrete over two miles long, extending from Galveston Island to the mainland.

Great credit is due Mr. Blodgett for the successful completion of this work which required the solution of new and difficult problems.

If you are not already a reader of the Iowa Engineer you should subscribe at once in order to secure the December Issue. This will a Special Highway Number containing contributions from leaders in Highway Work so that something very good is assured.

There will be inaugurated at Iowa State College during the coming winter vacation a short course in Highway Engineering. To our knowledge this is the first attempt that has ever been made to present a technical subject in this manner.

At this course it is purposed to give in a condensed form instruction on the fundamentals of Highway Engineering. The work given will be of a very practical nature, and topics discussed that an equal value and interest to those not actively engaged in highway work as well as the practicing engineer. Highway engineering is destined to occupy an important field, offering excellent opportunities for those familiar with this phase of engineering work.

The presntation of the course is under the auspicies of the Highway Commission, which has carefully organized the work, and taken considerable pains to obtain a competent staff of instructors. Engineers who are specialists in their line and who are actively associated with Highway Engineering practice and who are of the highest reputation have been secured to teach the various courses. Since the success of such an undertaking is largely dependent upon the leaders, the success of the new engineering short course is already assured.

College Notes

SENATOR KENYON TALKS ON SUCCESS OF LIFE.

Senator Kenyon addressed the student body at special convocation services Monday forenoon, winning a place of respect and admiration in the heart of every one present because of his clever story telling, his serious and logical philosophy of life and his strong, dominant personality.

As the senator did not come prepared to make a speech, he took occasion in the way of an introduction to tell a few choice stories which were received with enthusiasm by the audience. After securing the sympathy of his hearers he proceeded to comment upon Iowa's greatness as a state, and upon progress of this age. After taking a clever shot at the Ford auto, he proceeded to a more serious discussion of life, using as his theme the great question of the day, "What is Worth While in the World?" To answer this or at least to aid all in answering it satisfactorily he built a triangle representing the three factors of success.

He gave as a base of the triangle character. One cannot build for success if he does not have as a foundation stone character. "Horace Greely on his death bed, as he lay there thinking back over his tumultuous life, said, 'Popularity is an accident, riches take wings, the friends of today will curse tomorrow, but there is nothing that endureth as character.' " For one of the sides he gave courage and quoted Macbeth, "I dare do all that becomes a man. He who dareth more is none." The last side was service. He spoke of it as follows in his closing remarks, "The problem of humanity that faces young people is what is worth while; whether to go out solely to make money or to make things better for other people. You cannot put money in the shroud, for there are no pockets there. Found your life on character, defy everybody or everything, and then go out into the world for service."--*Student*

Tau Beta Pi, honorary engineering fraternity, has elected members from the Senior class. To be eligible a man must stand in the upper quarter of his class. However, scholastic

attainments alone do not qualify a man; he must show activity in college affairs, be courteous and resourceful; in short, be the true type of a man.

The men receiving the honor of election are:

Herbert A. Selindh, M. E.
Charles U. Hutchinson, E. E.
Paul B. Reis, C. E.
Charles W. Beese, M. E.
Charles E. Ide, E. E.
William H. DeButts, C. E.

CONCRETE STACK IS UNSATISFACTORY.

Construction has been temporarily suspended on the new 225 ft. concrete smoke stack at the college heating plant.

The advisability of such a stack being erected was questioned by smoke stack authorities from the start, and for this reason an investigating committee was appointed to see that the work was done correctly.

"Careless work featured the construction on the stack from the start," was the comment of a member of the committee, "and for this reason further construction was stopped."

Upon investigating the materials being used in the stack, it was found that river washed gravel was being used as an aggregate. This fact was criticised by the committee, in that such an aggregate furnished no adhesive surface to which the cement might cling. Further investigations resulted in a criticism concerning the method of applying the concrete to the forms. The concrete was being spilled a distance of 20 feet below the mixer onto the foundation of the stack. The down pour of the cement forced the smooth gravel to the outer surface of the stack, where it could be easily knocked off leaving an undesirable surface.

Construction was stopped at this time and the faults unearthed by the committee were ordered to be made right. Satisfactory arrangements were made and construction was continued up to the first of the week, when a second halt was called on the work.

A late report is to the effect that the stack would not stand, should it be built to the proposed height of 225 feet, and the indifference of the construction company to supply new forms in order to insure a smoother and more uniform surface indicates that the stub now standing may be torn down.

The football season is all but gone and Ames has few victories to her credit. The Cyclones started the season with but four veterans. Through hard and consistent training the raw recruits were whipped into a football team. The results of the games are as follows:

Ames 6—Grinnell 0 at Grinnell.
Ames 0—Minnesota 25 at Minneapolis.
Ames 37—Washington 7 at St. Louis.
Ames 13—Missouri 21 at Ames.
Ames 9—Nebraska 18 at Ames.
Ames 7—Iowa 45 at Iowa City.

Drake alone remains to be played. The team is not to be censored, for they have fought to the finish. As an Iowa player put it, "Ames died fighting us." The prospects for next year are promising and with the introduction of newer tactics the Cyclones should easily regain their former prestige.

The extension work at I. S. C. is now to have a home of its own. That part of Morrill Hall formerly occupied by the library is being remodeled and will be turned over to the extension department.

The basement will be used for bulletin and mailing rooms, and the first floor for offices.

This move has been made necessary because of the great amount of work being conducted by the department.

Alumni Notes

W. M. Wilson, M. E. '00, is now assistant professor of structures, in the University of Illinois.

Geo. R. Boyd, C. E. '06, who has been for several years chief engineer of the Brett Engineering and Contracting Company, at Wilson, N. C., has opened an office of his own as drainage engineer in Atlanta, Ga.

R. W. Clyde, for several years assistant engineer on the Guantanomo and Eastern Ry., Cuba, has now returned to the United States and is engaged in engineering work in Colorado.

J. B. Sullivan, C. E. '13, is located at Davenport, Ia.

C. H. Glaze, M. E. '13, is instructor in manual training in the high school at Cloquet, Minn.

R. Kuempel, M. E. '13, is in the automobile business at Guttenberg, Ia.

W. P. Nemmers, C. E. '12, was married during September to Miss Essie Cunningham of Des Moines. Mr. Nemmers is located at Waterloo.

Bryce Hutchinson, Mn. E. '09, is located in Ogden, Utah. He is employed by the gypsum interests at Ft. Dodge, Ia.

M. A. R. Kelly, Ag. E. '13, is in charge of work in Agricultural Engineering at the University of Missouri.

E. L. Fischer, E. E. '12, has a position with the Ft. D., D. M. & S. Ry. at Fort Dodge.

F. O. Boden, C. E. '12, is located at Marshland, Oregon.

R. L. Cooper, C. E. '07, is chief engineer of the Ft. D., D. M. & S. Ry., with headquarters at Boone.

Lee Taylor, Mn. E. '12, in the employ of G. S. Lodwick, and formerly located at Mystic, Iowa, is now located at Diamond, Iowa.

F. E. Cave, C. E. '08, is county engineer of Butler county.

Amos Melburg '13, H. B. Armour '13, O. N. Gjellifold '12, B. L. Taylor '12, J. C. Kerrigan '12, and C. A. Cool '12, are some of the recent graduates who have been given positions as county engineers under the new highway law. Melburg is in charge of Benton county, Armour of Ida county, Gjellifold of Winnebago county, Taylor of Woodbury county, Kerrigan of O'Brien county, and Cool of Waverly county.

H. B. Tyson, Mn. E. '12, was married October 15, at Deming, New Mexico, to Miss Anna Dermont.

Following is a partial list of the engineering alumni who were here for the Ames-Nebraska game, November 1:

Charles Capper. C. E. '13.

P. H. White, M. E., '09, Hamilton, Ill.

C. W. Eby, C. E. '10, Waterloo, Iowa.

H. J. Carson, M. E. '10, Muscatine, Iowa.

E. C. Cutler, M. E. '13, Omaha, Neb.

L. E. Corey. C. E. '13, Monroe, Ia.

G. S. Conley, E. E. '13, Webster City, Ia.

W. H. Kuhn, E. E. Ex '04, Council Bluffs, Ia.

C. G. Snyder, E. E. '09, Omaha, Neb.

Bert German. M. E. '95, Des Moines, Ia.

T. W. Dodd, C. E. '03, Des Moines, Ia.

C. H. Currie, C. E. '05, Webster City, Ia.

R. L. Cox, C. E. '05, Webster City, Ia.

E. M. Westbrook, C. E. '13, Chicago, Ill.

G. H. Stuart, C. E. '06, Boone, Iowa.

H. B. Armour, C. E. '13, Ida Grove, Ia.

H. P. Allstrand, M. E. '13, Clinton, Ia.

Clark Mosher, C. E. '11, Sioux City, Ia.

J. A. Illeman, C. E. '13, Boone, Ia.

G. J. Long, E. E. '11, Webster City, Ia.

H. A. Liser, M. E. '12, Waterloo, Ia.

C. H. Shuemacher, M. E. '12, Kankakee, Ill.

F. G. Austin, C. E. '10, Webster City, Ia.

R. E. Austin, C. E. '04, Webster City, Ia.

Oscar Edwards, E. E. '09, Sioux City, Ia.

Frank O. Jones, C. E. '10, Fairmount, Minn.

C. W. Roland, C. E. '03, Des Moines, Ia.

A. E. Wallace, C. E. '13, Jackson, Minn.

HIGHWAY EDITION

THE IOWA ENGINEER

CONTENTS

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Campus Bridge, Iowa State College. Reinforced Concrete, Skewed Arch, 20 ft. Span, 30 ft. Roadway. Designed and Built by the Iowa Highway Commission, Ames, Iowa.

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Essentials of a Good Road Law

J. E. BRINDLEY*

It is not too much to say that the so-called Balkema-Brockway Committee Road law, enacted by the Thirty-fifth General Assembly of Iowa contains the essentials of scientific road and bridge legislation in a higher degree than any similar measure enacted by an American state. While other states may have provided for the construction of so-called hard surfaced roads, or may possess here and there certain special advantages in comparison with the highway law of this state, the fact remains that, judged as a comprehensive administrative measure whereby the State Highway Commission, acting through its field engineers and other employees and county and township officials, may exercise a substantial measure of real supervision over the entire highway system of the state, the Iowa statute is in a class by itself and will, no doubt, serve as a model administrative law for sister commonwealths.

First of all the Iowa road law presents a continuous plan and logical purpose beginning with the work of the civil township and ending with that of the State Highway Commission, which is sadly lacking in the highway legislaton of practically all the other states. The township road superintendent is re-

*Professor Economic Science, Iowa State College

provided, shall be furnished by the State Highway Commission."

In the second place the law clearly provides for an equitable distribution of power and authority between the township, county and state, by giving to the civil township practically a complete supervision of 85 to 90 per cent of the roads included in the so-called Township Road System and reserving to the proper county officials the supervision and control of the remaining 10 to 15 per cent or, in other words, the highways connecting the leading market places and known as the County Road System. No real power was taken from the local units of government by the road law under consideration. Indeed, more authority may actually be exercised, especially by the county, than under the old system. The power of the State Highway Commission is exercised: first, for the purpose of maintaining the necessary uniformity of administration; and second, when local officials fail to perform the duties clearly outlined in the statute. For example, the classification of roads within each county is made by the county road engineer acting under the instructions and general supervision of the county board of supervisors; but it is obvions to any student of the good road movement that the surveys of the ninety-nine counties must be corrected and approved by the State Highway Commission in order to insure a continuous net-work of state-wide roads. Again the plans for permanent road improvement are worked out by the township road superintendent and county engineer under the dual supervision of the proper local officials and the State Highway Commission.

Finally, it should be noted that the Balkema-Brockway Road Law makes necessary provision for a complete system of auditing and accounting and prohibits the paying out of public money before work is actually done, and done in conformity with the plans and specifications. In the county "All bids for road work, tile and tiling, culvert and bridge construction, etc.", must be filed in itemized form by the county engineer before being allowed by the board and it is further stipulated that "a violation of this section shall render the county auditor liable on his bond for the amount of said warrant." In the civil township the same general requirement prevails. The

township road superintendent must approve bills and a violation of this provision of law makes the township clerk liable on his bond for the amount of the warrant issued. When we bear in mind the substantial measure of general supervision and control exercised by the State Highway Commission, it becomes apparent that the loose methods of accounting and paying out of the public funds, which formerly prevailed, can no longer exist. Thus in the classification of roads, the uniform requirements as to surveys, profiles, plans and specifications, and lastly, the definite location of financial responsibility, the State of Iowa may well be proud of the highway law enacted by the Thirty-fifth General Assembly.

The Highway Engineer-Qualification and Duties

PUBLIC necessity is producing a versatile individual in the person of the highway engineer. The demand for men trained for the work exceeds the supply and he must become a teacher establishing new courses of study and a distinct line of education. The public is calling for substantial and accurate information relative to highway improvement and he must appear as a public speaker, converting scepticism and dispelling opposition. New laws involving administration of public affairs, bond issues and new public policies are being written and he is called upon to advise. New departments of national and state and lesser units of government are being formed and he is placed in responsible charge. New standard of construction, the use of new materials or the new use of old materials must be developed and this is fundamentally his sphere.

In the United States much money has already been spent for road purposes. In the Mississippi Valley States the millions of dollars still unspent for such improvements cannot be foreseen.

Given a field unlimited in size, a profession unhampered by tradition or caste and an opportunity for the broadest public service, the highway engineer, present and prospective, must bring in fair payment, an open mind, conceding the right of the other fellow to his own point of view; integrity, active, not passive ideals large enough not to be mistaken for small ideas.

In our own state, the new year 1914 extends every encouragement to the highway engineer.

—*PROF T.H. McDONALD, B.C.E. '04.*

The Great Lincoln Trans-Continental Highway

FRED T. GRENELL

A keener interest in improved, standardized highways is being shown today in the United States than ever before so that the proposition to build a continuous, connected thoroughfare from the Atlantic to the Pacific, to be known as the Lincoln Highway, in memory of Abraham Lincoln, has aroused widespread enthusiasm.

Less than a year ago Carl G. Fisher, of Indianapolis, brought forth the plan for a coast-to-coast road, and today, it is declared his plan is certain to succeed. What this means to every interest, every class of citizenship, the farmer, the merchant, the manufacturer, the salesman—everyone, cannot be told in a few lines.

When good roads were first projected through the farming district they had no stronger, more enthusiastic advocates than the farmers. They subscribed money, labor and material. They permitted themselves to be heavily taxed and these "good roads" were "built." Most of them lasted only a few months. It would have required fabulous fortunes to even keep them

A Stone Arch Bridge on the Old National Road, now a part of the Lincoln Highway. Built in 1826 and still in perfect condition

in repair. Part of this was due to ignorance of the road makers but principally because the local politicians, working with the contractors, absorbed too much profit. In other instances the art of road building was not considered from the standpoint of maintenance and the changing character of vehicles which today pass over our highways were not provided for.

The farmer and the merchant of the smaller cities now agree that good roads add 50 per cent to the prosperity of the community. The automobile owners and the business men of the city of course, found this out years ago, else most of our city streets would still be unpaved. So when the Lincoln Highway was projected questions taken up were: First, the expense; Second, scientific building and supervision with consideration of drainage, natural materials at hand, etc.; Third, the cost of maintenance.

On the first proposition it was found that $10,000,000 would be sufficient to place a hard surface on the roadway to be improved. On the second item concrete was decided on because of the success with which concrete has met all traffic conditions, particularly in Wayne County, Michigan, where over 100 miles are laid. The third proposition is dependent on the second and in this respect Wayne County is again referred to, the maintenance in the county per mile of concrete highway, including the cleaning of ditches being less than $5 per mile.

The Lincoln Highway when completed will be the longest, connecting improved highway in the world. The association expects the local communities in most instances to prepare the roadbed under the specifications adopted by the engineers of the association. Long stretches will undoubtedly be completely built by many of the states. The funds now being raised are to take care of those sections, particularly in the arid west, where population is sparse. Yet it has already been found that help will not be as greatly needed as first thought as the counties are bonding themselves to insure the greater proportion of the expense of improvement. The route selected is that named after a careful survey of all the principal roads by engineers and officers of the association. It goes through thirteen states, starting at New York and ending in San Francisco, and takes in New York, New Jersey, Pennsylvania, Ohio, In-

A View along the Lincoln Highway in the Western part of Nebraska, Illustrating a Section that will need considerable Improvement

diana and Illinois in the east with those states traversed by the old Overland Trail, Iowa, Nebraska, Wyoming, Colorado, Utah, Nevada and California in the West.

Funds for the Lincoln Highway are being raised by many organizations and numerous individuals. State and district consuls have been appointed for each section, local banks are being employed as depositories and over half of the amount desired is already in hand or has been pledged. Sums have been given as low as $5, for one of the regular contributor's certificates, and as high as $300,000. The automobile manufacturers and their allied interests are greatly interested in the success of the association but other business is represented because good roads bring business to everyone. Everyone is being asked to contribute, not only those along the highway, because the Lincoln Highway, it is believed, will be a model thoroughfare, to be copied by others and to stimulate good road building in all states. Neither government or state aid has or will be asked.

Further in naming this coast-to-coast road the Lincoln Highway in memory of the martyred President, its founders believe

they have at last entered on a work which will be suitable in character and permanent in form as a great and lasting tribute to this country's greatest martyr. "The Lincoln Way" as it will eventually be known, has already stimulated and renewed the interest of the younger generation in him and those who contribute will assist in keeping his femory as perpetual as the life of the nation.

The greatest difficulties that come in the administration of a new bridge law or a new road law arise, not from the principles involved or the means necessary, but from particular selfish interests that would use, if possible, opposition to public improvement as a means to their own selfish advancement. Such thought did not actuate Abraham Lincoln. If the same generous and unselfish spirit can work the building of the highway dedicated to him that actuated Abraham Lincoln from his birth in 1809, until his death, April 15, 1865, its success is assured. It's influence on those who are yet to live in the Mississippi Valley is unmeasured. If there is anything to be desired to make this highway a success it is not great appropriations or help from outside sources, but a spirit marked by the unselfishness, the calmness, the sincerity of purpose of our martyred President, Abraham Lincoln.

"Oh, slow to smite and swift to span,
Gentle and merciful and just;
Who in the fear of God didst bear
The sword of power, a Nation's trust."

—*Prof T. H. MacDonald*

Training Highway Engineers at Iowa State College

T. R. AGG *

Prof. T. R. Agg

Because recent legislation and public opinion seem to be demanding that highway work be placed in the hands of skilled engineers, and preferably those who by training and experience are specially fitted to do it, Iowa State College has enlarged old courses and established new ones to meet the situation. It now gives undergraduates a chance to qualify themselves to enter this new field, which in salary and term of office, promises as great opportunities as some of the older fields, such as railway engineering.

No violence has been done to the sound principles of engineering education in establishing this new work. It is conceded that this new instruction should not displace any courses that are essential to a thorough general training in civil engineering. The undergraduate student is not always qualified to judge as to the field for which he is best fitted, finding his place only after some years' experience, sometimes being forced into lines of engineering entirely foreign to anything he had considered while he was in college. He may even find an opportunity in some commercial field not directly related to civil engineering, but for which he is fitted because of his personality or by the general training of his college course. The student should, therefore, receive a thorough training in those exact sciences that are the basis of engineering practice and which are invaluable as general training, before he is per-

*Professor Highway Engineering, Iowa State College.

mitted to specialize along any line. A careful analysis of the courses in civil engineering offered by colleges of good standing shows, however, that there is an opportunity to give during the junior and senior years a certain amount of special intruction in highway engineering and allied subjects without displacing anything of a less specialized nature.

Since highway construction is usually financed by taxation and is apparently to be administered through centralized authority, the student should gain some knowledge of the relation of highway improvement to the comfort, health and prosperity of the country, should be cognizant of the principles of equitable taxation for such purposes and should understand what are the basic principles of a rational workable system for expending public money on highway improvement. A course in highway economics has accordingly been offered in the junior year which deals with methods of promoting, financing and administering highway improvement.

The design of roads and pavement is based upon a knowledge of the behavior of various materials under traffic and the problem of design is to assemble the available materials into the most durable combination possible. The value of most road materials can be determined by laboratory tests which have been in use for a sufficient time to have enabled engineers to interpret them in accordance with the results obtained with the materials in service. A proper part of the training of the highway engineer is, therefore, the study of the laboratory tests usually specified for road materials and such a course is offered in the senior year. With the development of the bituminous pavement a field has been opened which requires of the engineer an intricate knowledge of the characteristics of a large number of complex compounds and much experience in their manipulation. While it is manifestly impossible in the undergraduate laboratory course to give to this subject the time necessary to master it, yet a study of road materials is incomplete without some time being spent on it. A part of the laboratory time is, therefore, devoted to the study of bituminous materials and the significance of the tests usually specified for them.

It is important for the highway engineer to know in detail

the approved methods of constructing roads and pavements. In the course at Iowa State College much emphasis is placed on the study of types of roads and pavements, the cost of each, their relative durability, the best construction methods, and the kinds of machinery to be used. In this course a proportional amount of time is spent in a study of the importance and economy of systematic maintenance.

Perhaps the most difficult and yet one of the most important duties of the highway engineer is to prepare contracts and specifications for road improvement. This requires not only a thorough knowledge of the details of construction, but the exercise of plenty of good sound sense to insure that both the public and the contractor are treated fairly. All students in civil engineering at Ames are required to take a course in contracts which is given in a very excellent manner by the mechanical engineering department. In the course in highway engineering still further instruction is given in the basic principles of highway specificatons and a detailed study is made of approved specifications for road work. Since the exact form which the specification may take frequently depends upon legal requirements under state laws or upon the system of administration under which the work will be done, a study of highway laws and of methods of administration is made along with the work in specifications.

The object of much of the instruction in highway work is to prepare for designing roads and pavements and in the senior year emphasis is placed on this subject. The student is required to make the surveys and prepares the plans, specifications and estimates for roads and pavements of various types using the traffic census as a guide in determining the type, and general design of the improvement.

The purpose of the undergraduate work in highway engineering is not to develop specialists who are trained in their line at the expense of their general training in the fundamentals of civil engineering, but to give special instruction principally in the senior year, which has a value in developing clear reasoning and mental resourcefulness as great as the subjects which are displaced and at the same time prepares the student to readily fit in on the force of a state highway department or

with a contractor on road work. Every effort is made to impress the idea of a proper ethical ideal in public service and the importance of harmonious relations with the many public officials with whom the highway engineer must deal. And finally the student is taught those fundamental principles and details of construction that he must use in practice together with the value of clear English and rational requirements in specifications and of well considered and complete plans for roads and pavements that are to be built by contract.

There is reason to doubt the value of a post graduate course in highway engineering to an engineer who has an opportunity to become associated with the work of a state highway department in any responsible capacity. It is believed that the things that can be taught in a post graduate course can often be learned more thoroughly in practice and that if the engineer in practice keeps in touch with current literature on the subject, attends the great conventions held by various highway associations and occasionally inspects the work of the State Highway Departments other than the one with which he is connected, he will secure a training much superior to that which can usually be given in a post graduate course. Not all engineers are, however, so fortunate as to be able to secure positions in which the opportunity for such development is offered and such men would undoubtedly find it worth while to spend a year or a part of one in resident post graduate study and to such men Iowa State College offers advanced courses in all lines of highway engineering with ample opportunities for experimental and investigative work.

The big new campanile of the University of California at Berkely is a notable structure. The tower is 300 feet high and will contain a total of 498 tons of steel in its frame. It is 34 feet square at the ground tapering to 30 feet. It will contain a clock whose dial is 15 feet in diameter, and be surmounted by a huge bronze lantern. F. A. Mosher, B. C. E. '13, is engaged in the steel work of the tower.

Federal Aid in Road Construction*

DAVID F. HOUSTON+

No one questions that the states and localities should largely contribute to the support of roads, and I take it, in view of the state of mind of the public, as expressed through its unofficial as well as its official channels, and through concrete legislation, that discussion of the wisdom of Federal encouragement and aid would be merely academic. The main questions for consideration are questions of the extent and character of such aid, and of methods and machinery, Federal, State or local.

The suggestion of great national trans-continental roads appeals to my imagination, as does the suggestion of interstate roads connecting capitals or cities of commercial importance to my logical faculty and to the sense of pleasure that I experience in riding about the country in my friends' automobiles. But that the essential thing to be done is the providing of good roads which shall get products from the community farms to the nearest station and make rural life more profitable, comfortable and pleasurable I entertain no sort of doubt; and it is obvious that the representatives of the people in Congress are like minded. For in making their appropriation they stipulated that it should be used in improving the conditions of post roads with a view to the economy and efficiency of postal delivery and for the transportation of farm products to the market. Such roads are equally essential to the establishment and operation of decent elementary and secondary schools for the benefit of the country boys and girls. I do not eliminate other things from consideration and I do not underestimate the rights and pleasures of the automobilists and the service they have rendered in the propaganda for roadbuilding.

APPORTIONMENT OF AID.

Who shall say how aid should be apportioned so that the states may receive equitable treatment? Shall it be apportioned equally among the states on the basis of total population, farm population, area, taxable valuation, road mileage, or all these; and should

*Engineering Record, October 11, 1912.
+U. S. Secretary of Agriculture.

Federal money be expended exclusively through its own agencies for a certain system? What roads are to be improved? There are approximately 2,250,000 miles of publicly owned roads in the nation. Half of this mileage is utilized for post roads and less than ten per cent of the total can be classed as improved in any large sense. Shall we undertake to apply aid to all the roads or shall we consider this a task too gigantic? Shall we apply it to the rural routes or shall we regard this as equally beyond reason? Or shall we single out certain directions in which central roads shall run, and, if so, how? Is it not clear that this opens up a field where petty politics, community interest and individual selfishness may run riot? Assuming that we have settled this, for what purpose shall the aid be granted and in what proportion? Shall it be exclusively for construction, exclusively for maintenance, or for both? Shall it be to pay the entire cost of either or both of these items, or shall it be dependent on the equal or larger contribution by the states and communities? Shall the aid come through votes of money out of the treasury or from the sale of bonds?

That the suggestion of Federal aid to roadbuilding raises grave questions and involves possible dangers no thoughtful citizen doubts. There are proposals before the public mind which would bankrupt the Federal Treasury and suggest possible abuses before which those of the worst pork-barrel bills of the past would pale into insignificance. No proposal which does not carry with it the assurance of safeguarding the treasury in this direction seems to me to stand the ghost of a chance of favorable consideration. It is not alone the fear that there would be no stopping place. There is the question of precedent, for this is not the only proposal before the American Congress involving the suggestion of huge appropriations.

It would be especially pernicious if such aid should result in stifling the spirit of local self-help. In this field as in others the states have recently made great headway, and any action taken should unquestionably result in the fostering of this spirit and in the efficient direction of the activities to which it may lead.

Another difficulty to be avoided is the over-centralization of activity in these intimate internal matters and the building up

of a great and powerful bureau in Washington, with an ever-increasing control over the highways of the country. The dictates of prudence and experience are that so far as possible such agencies as may be required should be efficiently developed in the several states and that the Federal agencies should work in a spirit of complete and helpful co-operation and assistance.

STATES AS ROAD UNITS.

The first practical essentials in the planning of road legislation would seem to be to recognize the state as the smallest unit with which the Federal Government might deal. This would give relief in a measure from the insistent demand that would come from every township and every district in the Union for its share of state or Federal assistance, without reference to the merits of the case or the practicability of the undertaking. Many of the states now have efficient state highway departments and thus afford organized agencies with which the Federal office could deal. It would seem that the basic feature would be such co-operation between the states and the Federal Government as would leave with the states the initiative in the selection of roads to receive aid, and as much of the immediate construction and maintenance as would be practicable. In the case of roads on which Federal money is to be expended it would seem essential and wise that the Federal agency should have the requisite power of the approval of the selection, supervision of the construction and maintenance, and the right of inspection, for the plain and simple ordinary purpose of seeing that the Federal money is applied to the purpose for which it was voted and is efficiently expended.

It is reasonably clear that for every reason there must be some automatic check upon the demands to be made upon Congress and that this should be afforded through the requirement that the states and the localities should contribute an amount both for construction and maintenance at least equal to and possibly double that contributed by the Federal Government; and that, in the apportionment of any possible Federal funds, a number of basic factors, such as population, area, wealth, or minimum cost of construction, should control.

In short, as a practical program, I believe that this matter is one in which haste can best be slowly made. The people will

sanction a reasonable expenditure of their money—and it is their money, and theirs only, whether it be expended through the Federal Government or the state—when they are convinced that it is applied to a wise purpose and will yield the results anticipated. And I am impressed by the wisdom of the action of Congress, in the midst of so much clamor, in constituting a committee "to make inquiry into the subject of Federal aid in the construction of post roads," in providing an appropriation of $500,000 to be expended co-operatively with the states in the proportion of one to two, and in requiring the Secretary of Agriculture and the Postmaster-General to report to Congress the results of such expenditure, "together with such recommendations as shall seem wise for providing a general plan of national aid for the improvement of postal roads in co-operation with the states and counties, and to bring about as nearly as possible such co-operation among the various states as will insure uniform and equitable interstate highway regulations." This indicates a wholesome desire to know the facts as well as a generous interest. Too short a time has elapsed to judge of the value of this undertaking, but that it is in the right direction few will question. That it might be extended with ample funds if aid is to be furnished most thoughtful men would concede; and the plan has the peculiar value of being susceptible of indefinite extension in case the results should be found to justify it.

Concrete Country Road in Cerro Gordo, County, Iowa

J. S. DODDS, B. C. E. '12*

Cerro Gordo county has the first mile stretch of permanent road built in Iowa. It was built on the worst mile of the road between Mason City and Clear Lake about midway between the two cities at a cost of $10,646.72 or $1.124 per square yard. This cost includes almost $1,000.00 spent for grading the road preparatory to paving. Of the above $10,646.72, $2,250.00 was donated by interested parties owning property adjoining the road and by the cement companies of Mason City. It is believed that for work of this character a much larger proportion of cost will be contributed by parties interested locally after the advantages of this type of construction are made apparent.

This mile of concrete road is sixteen feet wide with four foot gravel shoulders on each side sloping to good side drainage ditches located ten feet from each edge of the paved portion. It is, without doubt, as good a concrete road as can be made and there is no better road of its kind in the United States.

The supervisors called on the Iowa Highway Commission to send an experienced concrete road engineer to assist them in getting the work well organized and they had every detail figured out beforehand to avoid delay when work was once started. Being prepared for construction when it was ready to start made economy possible when actual work was commenced. The concrete was all laid in less than twenty days after the mixer was started.

Special difficulties are met when concrete road building is carried on away from cities; water supply, which must be constant for mixing concrete, becomes a problem and hauling material constitutes a very large item of the cost as distance from shipping point increases. In many localities, farther removed from sources of supply, this hauling could only be done economically with trains of dump wagons propelled by tractors and loaded by special machinery. On this Cerro Gordo county work,

*Head of Eduactional Dep't., Iowa Highway Commission

A View of Cerro Gordo County's, Iowa Concrete Road Work showing how Material was arranged ready for mixing gang

however, the road was less than two miles from a railroad siding and a good source of sand supply was developed less than a mile from the work on land belonging to the county. Hauling was therefore possible with team and wagon. Dump wagons should be used on work of this character to obtain the best results. Water for steam engine, mixing and sprinkling was provided by a gasoline engine driven duplex pump direct connected to a two and one-half inch pipe line about three thousand feet long. This pipe line was laid on the surface along the fence line at the side of the road. It was provided with hose connections and valves at intervals of two hundred feet. These were used for attachment to the mixer, boiler and for sprinkling. The water was pumped from a creek crossing the road near the quarter line, against a gravity head of about fifteen feet and a friction head of about thirty-five feet for maximum length of pipe. Gasoline consumption was about three gallons per day of nine hours. A safety valve at the pump prevented an excess of pressure on the line.

The mixer was a Koehring street mixer loaned by the Iowa

Highway Commission. This mixer has been in use two seasons laying concrete roads on the campus of the Iowa State College at Ames. An average of five hundred square yards per day of seven-inch pavement is easily made with this outfit and twenty men.

Expansion joints of the armored type were provided every twenty-five feet. One-quarter inch of asphalt filled felt was used to fill the joints. This type of joint obviates the necessity of setting forms to secure proper cross section of the road.

The material used was all secured in Cerro Gordo county. The cement was the product of the local mills; the crushed rock came from the Mason City quarries; the gravel was furnished by a local pumping plant. These materials were shipped from Mason City to Emery siding, which is less than one mile from the west end of the work. The sand was excavated on the section of land adjoining the road on the south. Iowa is especially favored in having a plentiful supply of road building material fairly well distributed throughout most of the counties. The materials used were first-class in every way and the concrete was made of one part cement, two parts sand and three and one-half parts of

A View of the Finished Concrete Road Work before the Shoulders were laid between Mason City and Clear Lake, Iowa

coarse aggregate, either the gravel or the crushed rock, up to one and one-half inch size.

For side forms two-inch by six-inch lumber was used and held to line and grade by iron stakes driven in the ground. The surface of the sub-grade was carefully leveled just before laying the concrete and was kept well saturated with water. The sub-grade was flat and extra thickness of concrete was obtained at the center by crowning the road one and one-half inches in the sixteen feet. This made a road six inches thick at the edges and seven and one-half inches thick at the center. Labor for this work was furnished by Russian beet field laborers of the neighborhood. Slight labor troubles were experienced at the outset because of a misunderstanding regarding terms of employment, but this was settled and these men were found to be a satisfactory source of labor.

Mr. Aaron Grimm, supervisor from Clear Lake, superintended the entire work personally and to his methods of handling men and materials should be attributed much of the success of the work.

Mr. B. H. Lampert was engineer on the work and the mixer crew was drawn from the paving work at the College.

Now that Cerro Gordo county has taken the lead in permanent bridge and road building, it plans to take up graveling the county road system as soon as it has been brought to line and grade under the Iowa law. It is this recognition of the value of proceeding under definite plans and specifications and the direction of an engineer that will make for real progress in road building in Iowa.

Illustrations of the work were furnished by Geo. E. Frost, county auditor of Cerro Gordo county.

The cost of the work has been tabulated and itemized by County Engineer Lampert as follows:

COST DATA ON CONCRETE ROAD, CERRO GORDO COUNTY, 1913.

		Per Sq. Yd.
Freight on mixer, Ames to Mason City	$ 30.00	
Freight on mixer, Mason City to Ames	26 64	
Freight on Baker joints	53.97	
Engineer Dodds' expenses	49.31	
	$160.31	.0170

Miscellaneous teaming, hauling pipe mixer, etc.....	$ 71.43	.0075
Oil, coal, gas, repairs	60.55	.0064
Miscellaneous labor unloading mixer, laying pipe, building culverts, lost time, etc	176.69	.0187
Lampert Engineering or foreman	125.00	.0132
Plant bought $523.48, 20% to job or	105.00	.0111

LABOR.

Average organization, wages paid 500 sq. yds. daily.

Men.	Job.	Rate.	Day.	Sq. Yd.
2	Finishing removing forms	$.400	$ 8.00	.0160
2	Striking off grading concrete	.275	5.50	.0110
1	Fireman on mixer	.350	3.50	.0070
1	Engineer on mixer	.400	4.00	.0080
2	Side forms and joints	.300	6.00	.0120
1	Cement	.300	3.00	.0060
2	Wheeling, shoveling sand	.275	5.50	.0110
3	Wheeling stone	.275	8.25	.0165
6	Shoveling stone	.275	16.50	.0330
1	Extra fixing sub grade	.275	2.75	.0055
1	Water boy	.100	1.00	.0020
1	Hose boy	.100	1.00	.0020
			$65.00	.1300

GRADING.

Grading about 3,100 cu. yds.			
Wheelscraper and wagon work	$ 497.25		
Loading wagons	60.00		
	$ 557.25	.18 cu. yd.	.0588
Surfacing	$ 307.50		.0325

MATERIAL.

Baker joints and felt	$ 536.40		.0566
Sand 874 cu. yds. taken from Co. pit			
Stripping pit	6.00		
Loading	123.50		
Hauling	243.00		
	$ 372.50	.426 cu. yd.	.0393
Crushed stone 560.74 cu. yds. at $1.00	$ 560.74		
Freight	285.09		
Loading	141.45		
Hauling	341.00		
	$1,328.28	2.37 cu. yds.	.1405
Gravel 855 cu. yds.	$ 595.04		
Freight	403.02		
Loading	123.50		
Hauling	493.00		
	$1,614.54	1.89 cu. yd.	.1705
Cement, 2,413 barrels at $1.56 on cars at Emery	$3,764.28		.4220
Hauling	217.17		
	$3,981.45		1.124

9,472 sq. yds. at $1.124, total $10,646.72

Note: Teamsters helped load material.

Sand was not screened and ran about 10 to 15% ¼" up.

This labor account is high because it includes the wages when we had more than twenty-three men around mixer, for when hauling was impossible we had the shovelers from the cars around the mixer also.

Donations:	
N. W. States Cement Co.	$ 500.00
Lehigh Cement Co.	500.00
Property Owners:	
C. H. McNider	500.00
Jas. Watts	500.00
O. A. Heddens	250.00
Total	$2,250.00

Concrete mixer furnished free by the Iowa Highway Commission.

IRON RUST---FACTORY, OCTOBER, 1913

What makes iron rust? Nobody knows exactly. Iron rust is iron ore. It is generally known that iron will rust whenever water accumulates upon it and oxygen has a chance at it. It is certain that electrolysis will promote rust but it has not been proven to be the immediate cause. Iron will not rust in the absence of water. There is an iron pillar in Egypt thousands of years old, exposed to the air, without a trace of rust on it. Distilled water is an excellent solvent of iron.

The corrosive action of acid depends upon the presence of oxygen in the acid solution. The more concentrated the acid the less marked the corrosion will be, for pure acid is shipped in iron containers. Practically all internal boiler corrosion and pitting may be charged to the presence of oxygen and carbonic acid, that is formed from carbon dioxide contained in the feed water.

Of equal importance to the cause of rust is its prevention. The methods commonly employed are painting, tinning, galvanizing or plating, sherardizing and concreting. The latter method is used by the large railroads on the steel members of train sheds and bridges subject to smoke and gases. The coating is applied with a special concrete gun using compressed air as a driving power.

Extension Work Makes a Good Start

F. W. BECKMAN*

Group of Cedar Rapids young Men enrolled in Ames Engineering Extension Courses in Drawing and Shop Mathematics studying at City Y. M. C. A.

The engineering extension work established by Iowa State College at Cedar Rapids is more than making good. Twenty-two young men from local shops and factories are enrolled in the courses in mechanical drawing and shop mathematics and. according to R. B. Dale, of the engineering extension department, they are faithful in their studies without exception, they are enthusiastic, and they are making rapid progress. Mr. Dale is in position to judge, for he handles the correspondence end of their work and marks and grades their papers.

At Cedar Rapids the classes are in charge of A. A. Soth, an Iowa State College alumnus who is now mechanical draftsman for the Denning Motor Implement Co. Eleven of his students are machinists, including apprentices, experienced workmen and foremen. Five tinners and sheet metal workers are also enrolled, and one woodworker, one laborer, four clerks and office men employed in factories. Seven of the men are from the J. G. Cherry Co.; four from the Denning Motor Implement Co., two from the Tourist garage, and one each from Douglas & Co.,

* Professor Journalism Courses. Iowa State College.

Quaker Oats Co., T. M. Sinclair Co., Cedar Rapids Foundry and Machine Co., Henry Zuber Hardware Co., Kings Crown Plaster Co., and the Linn County Coal and Lumber Co. These men are all ambitious to prepare themselves for better positions and they do their work with a zest that is refreshing.

The success of the classes at Cedar Rapids is being watched with keen interest over the state. Similar classes are being organized at Marshalltown, Mason City, Charles City, and Waterloo. Soon extension classes in gas engines and heating will be organized in Cedar Rapids and elsewhere when enough students ask for them.

First Annual Short Course for Road Builders

AMES, IOWA.
DECEMBER 29, 1913—JANUARY 7, 1914.

Road making has ceased to be a pleasant diversion for the slack time in the year's work. The road maker has need for better equipment than inherited fallacies and a "good eye." Road making has become a serious occupation. The well equipped road maker has all his opportunities before him.

Beginning on December 29, 1913, and continuing until January 7, 1914, the Iowa State Highway Commission will hold its first annual short course for road builders at the Iowa State College, Ames, Iowa.

This course comes at a time of the year when road work in the field is practically at a standstill. It comes when other duties are most easily laid aside. At this time it is possible to gather together many experienced men in the various lines of highway work to act as instructors and when the College of Engineering at Ames is available as a large class room and laboratory for the work.

All the road builders, whether engaged as county engineers or superintendents of highway construction, are urged to attend this course as it promises to be a valuable feature of the working out of the highway administration system in Iowa.

The purpose of the course is to present in a condensed form and in a short period of time a digest of the fundamentals of the best practice in highway engineering.

Campus Drive at Iowa State College, built by Iowa Highway Commission

The topics for the various lectures and demonstrations are those in which the engineer in practice is greatly interested, and are selected especially to afford county and city engineers an opportunity to secure additional technical training along modern highway building lines.

It is not the hope or intention to turn out efficient highway engineers in eight days, but to offer a convenient opportunity at a small expense for engineers now engaged in highway work or allied lines to secure a better knowledge of road construction and administration methods.

It is believed that this course will go a long way toward bringing the highway work of the state into uniformity and placing the work upon a firm professional basis. Good engineering demands that the road and bridge money of the state be expended economically for structures of a high degree of utility and permanence at a reasonable cost.

By a study of the program it will be seen that the course

includes instruction in the fundamentals of highway engineering and although a great deal of work is to be done in a short time, the instruction has been so organized as to permit of a presentation in considerable detail. The various experts who will be present at the session will, in addition to their regular lecture work give conferences to engineers who desire to discuss specific problems with them.

The instruction throughout is arranged primarily for highway engineers and only a few sessions are of such a nature as to be of any particular interest to others. The special evening lectures are, however, of a more general nature and will be open to the public in general, regardless of registration in the short course.

The list of instructors will be seen to include specialists in every branch of highway engineering, men who have actually gone out and made the funds at their disposal go farther and purchase more real value than any who have preceded them. These men will bring us real instruction in their respective lines.

The list includes state engineers, staff engineers of the Iowa Highway Commission, professors in the Civil Engineering Department of the Iowa State College, engineers of the National Office of Public Roads at Washington, and specialists in highway economies. These are men who not only understand the theoretical side of highway engineering, but are also well versed in the practical problems we all encounter in the field.

Dr. L. I. Hewes of the Office of Public Roads has been making a special study of the economies of road construction. Dr. Hewes spent some time in Iowa at the time the survey was made for the Iowa Post Road through Boone and Story counties. Since that time he has made some studies of roads in a number of different localities. He is sent to Ames by the Office of Public Roads who are also supplying a nice exhibit of views showing road construction in various states for use during the road school.

Mr. A. N. Johnson, State Engineer of Illinois, is recognized as one of the foremost authorities on road construction in the United States. He is chief engineer of the reorganized Illinois Highway Commission which will have next year, about three-quarters of a million state aid money to spend and which will be increased the following year to about one million dollars.

Mr. A. R. Hirst of Wisconsin is familiar with the practice of road building in the east as well as in Wisconsin where he has had charge of the road work of the Wisconsin Highway Commission for the past several years. Wisconsin state aid law is producing a large mileage of roads every year, many of them being of a class that would be adaptable to Iowa conditions.

Mr. Thos. H. MacDonald, Chief Engineer of the Iowa Highway Commission, has made a very close study of the construction and maintenance of earth roads during the past ten years, in which time he has had charge of the work of the Highway Commission. He is a recognized authority on earth road construction and maintenance, among the leading highway engineers of the United States.

Professor T. R. Agg only recently left the employ of the Illinois Highway Commission as road engineer, to accept a position to take charge of the highway work at the College. Mr. Agg has had a number of years experience in road work in Illinois and has made a specialty of concrete and bituminous road construction.

Kelbourn Bridge across Des Moines River, Kelbourn, Iowa. Designed by Iowa Highway Commission. F.R. White, B C.E. '07. Resident Engineer. T.H. MacDonald, B.C.E. '04. State Engineer.

All of the lectures will be illustrated with lantern slides.

Those intending to attend this course should register in advance for accommodations with the Highway Commission at Ames as early as possible.

INSTRUCTORS.

A. Marston, Chairman of the State Highway Commission.

A. R. Hirst, State Engineer of Wisconsin.

A. N. Johnson, State Engineer of Illinois.

T. H. MacDonald, State Engineer of Iowa.

Lawrence I. Hewes, Chief of Economics and Maintenance, Office of Public Roads, Washington, D. C.

J. E. Kirkham, Associate Professor in charge of Structural Engineering, Iowa State College.

T. R. Agg, Assistant Professor in charge of Highway Engineering, Iowa State College.

John E. Brindley, Professor of Economics, Iowa State College.

John Starr Coye, Chemist Good Roads Section, Iowa Engineering Experiment Station.

J. H. Ames, Office Engineer, State Highway Commission.

F. R. White, Field Engineer, State Highway Commission.

C. B. McCullough, Designing Engineer, State Highway Commission.

CONCRETE BUILDING FAILS

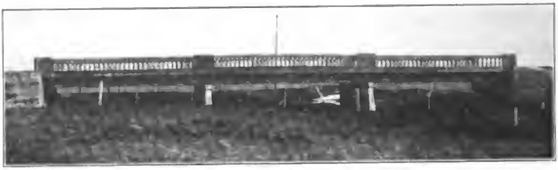
We note the failure on November 14th of a portion of the Stark Lyman building in Cedar Rapids. It was a reinforced concrete building, 140 ft. by 60 ft., and seven stories high. Forty feet of the rear end of the building collapsed. The roof was being poured when it gave away without any warning, and the superintendent, foreman and crew were carried down with it.

Many theories have been advanced as to the cause of the failure; the consensus of opinion seems to be that the failure occurred at the fifth floor, which was carrying the two upper floors and the roof.

The designing engineer was H. J. Bishop, and the contractors were Louritzen and Wasson of Waterloo. The steel designs were checked by Wm. B. Hough Co. of Chicago.

Experiences of Road and Bridge Work, Osceola, Co.

L. A. WILSON, COUNTY ENGINEER



96ft. Reinforced Concrete Bridge, Built 1913, Osceola Couuty, Ia.

Work under the new road law naturally divides into two classes, the grading and maintenance of roadways and the proper bridging of stream channels. In this locality, the Highway Commission plans for road grades come as a further departure from our former system than do their plans for bridges and culverts.

In general our county consists of a gently rolling prairie with probably 90 per cent of all our roads possessing a sufficient natural lateral drainage. The remainder lie through limited areas of low lands or through the flood plains of small streams where drainage is a difficult proposition until such streams are, at all times, confined to their channels. Until recently, we have made little progress with road grading beyond the construction of surface grades. Many of these grades are entirely too narrow and a goodly portion of such are worn down until the center of the road is too low to properly drain to the side ditches. Within the past few years, we have begun to drain out some of the low lands and to use the King drag quite consistently on our main roads. During the past seasons of dry weather, these low grades have been giving fair service and traffic has suffered little inconvenience by reason of muddy roads.

Work under the new law was begun in this county under the serious handicap of a shortage of local labor. This has prevented us from making more than a good start with our permanent grades. Where such grades were begun or have been completed, they contrast so sharply with adjacent roads that the traveling public has become dissatisfied with the existing poor grades. They demand that better grades be provided for gen-

eral traffic over the county while the permanent work is being done. Owing to the fact that it will necessarily take a number of years to complete the permanent grades and to the fact that the present limit of $35.00 per mile allowed for repair work, will not put our roads in passable shape; it seems that the complaint is properly justifiable. A solution of the problem, as it appears to the writer, is to construct a proper surface grade over the entire system of main roads which will conform to the Highway Commission cross section but which shall be essentially a surface grade throughout. The need of such a grade in this county is so great that it seems proper to say that it should be constructed as soon as possible. The work of cutting down the hills and filling the hollows should continue as rapidly as the road funds will permit and would seem to demand other labor than that of local farmers. In this locality, surface grades of the kind mentioned can be built at a cost of from $100.00 to $150.00 per mile. Such grades will undoubtedly do much to quiet any existing opposition to permanent grades, will provide better and safer roads for the continuous traffic that we now have and yet should serve to show to the people the limitations of a surface grade. From personal knowledge, the statement is made that conditions similar to our exist in several neighboring counties.

General satisfaction seems to exist in regard to placing all culverts and bridges in the hands of the supervisors. It would seem very advisable to extend the power of the supervisors to cover the entire mileage of the county; thus placing the whole of the road and bridge work under one head.

With regard to the erection of bridges, we have for some years been working into permanent types as rapidly as we could. We had, however, already begun to question the stability of some of these permanent types when subjected to our modern heavy loadings. Analysis of several bridge plans submitted led us to the belief that we could build with more safety under the State Highway Commission plans. In 1912 we rejected all bids on the types submitted by the contractors and called for bids in accordance with plans submitted by the Commission. We were unable to get satisfactory bids on these latter types and forthwith decided to try out the day labor plan to see whether or not we

could become independent of the organized bridge companies. Our first attempt was with a 36-foot reinforced concrete deck girder span for which our lowest bid was $1,940.00. We built it at a total cost of $1,340.00. It compares very favorably with any bridges that we have had erected by contractors. Since that time we have contracted for three steel bridges and have built seven concrete bridges by day labor. The enclosed photograph shows a bridge erected this summer just south of Sibley. It consists of three 32-foot deck girder spans, entirely of reinforced concrete, has a 19-foot roadway and cost $3,960.00. In doing our bridge work, we have had to develop our foremen and gangs from ordinary unskilled labor and have had to purchase or rent our equipment; yet have never had the slightest difficulty in keeping well below any bids that we have ever received for this class of work.

Future Policy of Road Work in Clayton Co.

E. B. TOURTELLOT, COUNTY ENGINEER

Iowa as a general rule has been rather conservative in the past in its road and bridge construction. Very little thought has been given to permanency and the work put upon our county highways has been chiefly repair work. The primary cause of the good road movement is the automobile, while the ultimate cause is the recent legislative action of our state, which aims at better and more permanent roads.

In looking into the future possibilities of our road system, we naturally turn to the county engineer, for upon his ability to develop the natural resources of his county; to use such to the best advantage; and to use economy in the expenditure of his county's funds, depends the success of the Iowa road law. In other words, the central idea in this whole issue, is the great question of the people's welfare. It is true that there are problems in all of the counties which are sure to tax the skill of the county engineer; problems such as drainage, protection from erosive action of streams, grade eliminations, bridging of streams, etc. At the same time, the engineer must endeavor to raise the standard of public opinion to a higher degree in regard to better road construction. He must convince the people that through

his efforts he is able to save money for the county, and at the same time, to build better roads and bridges than has been done in the past.

The natural resources of Iowa, as shown from a study of the geological map, are favorable for use in road building. There are large gravel beds in almost every county and limestone quarries are not a scarcity. Even in localities where quarries and gravel pits are not available, it will be possible and even economical to run spur lines to the nearest gravel pit or quarry and ship the road material in train loads to the nearest station. In the counties of rough topography the engineer will find his problems somewhat different from those which the engineers in the other counties of the state must face. One mile of road in Clayton or Allamakee county will require as much time to survey as three miles in Butler or Story county. The comparative cost of bringing this one mile to grade will exceed this ratio. The cost of surfacing, however, will be less. One good way of surfacing a road is to set aside a "good road" day. The farmers and towns people must be enthused to give a day to the building of a piece of road in their locality. Arouse public sentiment through the local papers; prepare the sub-grade and have the surfacing material ready; then, on the day set aside, be on the job and see to it that the road is surfaced as it should be. This has worked in other states and should work in Iowa.

The future policy of Clayton county will be to combine repair work with work of a permanent character. There are exceptions to this, of course, but on the whole it is believed to be more economical to spend the county's money on putting a piece of road into shape once for all. The county is now building a three-mile stretch of macadamized road, known as the Strawberry Point-Oelwein road. The work is quite difficult on account of two rocky hills which are being cut down six feet. The rock is a good quality of limestone and is crushed and used for surfacing. The road equipment consists of the following: Oil pull Rumely tractor, 30-45 H. P.; Austin-Western 10-ton roller, sprinkler, grader, rock spreaders, wheel scrapers, slip scrapers, complete crusher plant, including gyratory crusher, elevator, revolving screen, and three compartment bin; Ingersoll-Rand air compressor and "Jack Hammer" drill; and Adams "Giant"

road grader. The tractor is fitted with two pulleys in order to run both the air compressor and drill at the same time. The crusher plant has a capacity of about 18 tons per hour. The cost of this outfit is about $8,000.00 and is the first of its kind, it is said, to be installed in the state for county use. The work of removing the rock and piling it up ready for the crusher will be continued through the winter.

One of the greatest difficulties that the writer finds in road work is the problem of maintenance. It has been a hard proposition in the past to keep the roads repaired and especially to get them dragged at the proper time. The farmers are not to be blamed for their lack of interest in road dragging when it is a good day to plow corn or to harvest a crop. It is believed that the only successful method of dragging and repairing roads is to divide the county system into sections, the length of which will depend upon the topography of the land and the condition of the road, and to employ a man and team to keep each section repaired and dragged. In this way, steady employment will be given to the section boss, as he will be called, and a fixed salary will be paid. A well dragged and properly maintained road should be assured. The section boss will be provided with the necessary road tools and will have the power to employ a helper when it is necessary. He will also be under bond for the faithful performance of his duty. Clayton county will adopt this system for the ensuing year and it is hoped that better maintained roads will result.

The legislature has given Iowa a start, now let the county engineer, working in harmony with the State Highway Commission, give momentum to this good road movement.

Proposed Work in Louisa County for the Coming Year

M. L. HUTTON, COUNTY ENGINEER.

The proposed highway work in Louisa county for the season of 1914, is as yet unsettled, but the county engineer has recommended the following:

1. About ten miles of permanent grading.

2. Three day labor bridge gangs on permanent and repair work.

3. The purchase of a tractor outfit for crowning all county roads possible.

The intention is to construct all the smaller waterway structures with day labor gangs. During the season of 1913 there has been about 40 bridges and culverts of steel and concrete constructed since the 1st of June. A late start and a previously "crippled" bridge fund was the handicap this season. Next season should see the construction of many more permanent structures, surveys for which are being made at this time.

All permanent grading will probably be by contract and for minimum stretches of one mile. Owing to the topography of the county there are a variety of conditions and obstacles to overcome. Sand roads, clay hills, and boggy river bottom roads all create a different method of improvement to be followed, and all of which is necessarily more expensive than the improvement of plain prairie roads.

However, if the work as recommended is accomplished, a great advance will be made in highway construction work in this county, and the season of 1914 will have been a successful one.

THE IOWA ENGINEER

Published Monthly During the College Year by the Students of the Division of Engineering, Iowa State College, Ames, Iowa

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EDITORIALS

A good practicable and workable road law is indeed the first step in the direction of a satisfactory system of highways. The splendid results accomplished under the road and bridge law enacted by the Thirty-fifth General Assembly proves its usefulness and practicability. The law is far superior to that of any other state in its administrative principles and methods of accounting for the expenditure of all funds. Iowa was exceedingly fortunate in having the mistakes in the road laws of other states to profit by in framing her own law. The State Highway Commission, acting through its field engineers and county and township officials, exercises supervision over the highway work of the entire state. It is centrally located and clothed with the necessary powers and it can plan, organize and direct the policy of

road and bridge work of the state as a whole without delay, thus securing more uniform results. Again, the possibility of graft or unwise expenditure of funds is precluded by the provision for a complete system of auditing and accounting. In the course of a few years Iowa should be in the possession of as fine a system of roads and bridges as is to be found elsewhere, due primarily to the broad and comprehensive features of its road law.

Nearly every engineering graduate after a year or two of experience can look back over his college work and pick out some studies that he should have taken more seriously. It seems that engineering students in general are too apt to overlook the importance of English composition in connection with their technical studies. The nature of all technical work implies that engineers are constantly called upon to express themselves in logical, accurate and clear-cut language. Lack of ability in this respect, is, according to Mr. H. H. Norris, Secretary of Society for Promotion of Engineering Education, who addressed the engineering students at Ames recently, "a superficial defect of technical graduates which can largely be remedied while in college." One way to overcome this defect he says, is to have the right attitude while studying. The proper composition of laboratory reports is excellent training in this direction. The student should bear in mind that in all branches of engineering he will afterward be called upon to furnish intelligent reports closely similar to these.

In addition we might add that technical students should use more of the opportunities offered by college publications. Here is a chance for study and actual practice in printed compositions. We believe that more engineering students should be interested in this side of college work. It is with pleasure we note that in the near future courses in technical journalism will be offered at Iowa State College.

The first season's work under the new highway administration in Iowa is practically completed. Accomplishments in different parts of the state are varied. As an indication of what has been

done we are publishing statements from a few counties as reported by their county engineers. These reports also show how the highway law is operating in the particular localities. From time to time other reports will be published. We anticipate that these reports will contain opinions both for and against some of the provisions of the new law.

During the past few months much has been written and said concerning the Lincoln Memorial Highway. Interest in the undertaking is by no means confined to the territory through which it passes but is felt by people in adjoining states. Iowa is particularly fortunate in having the route of the highway cross the entire state from east to west.

It is proposed to surface the road with concrete, a form of construction which during the past season was first tried in Iowa on a sample mile between Mason City and Clear Lake. A good idea of this type of surface can be obtained from the article in this issue by Mr. J. S. Dodds, who had charge of the construction of this road.

During the past two years the scheme of national aid in the building of roads has grown greatly in favor. The plan has been extensively advocated; a bill appropriating a nominal sum for the improvement of certain post roads has been introduced into Congress; and committees of that body have been appointed to investigate the question more fully, and perfect if possible, a satisfactory and acceptable plan for national aid. In the report of the committee, of which Senator Bourne is chairman, a plan is set forth proposing the issuance of $200,000,000 of 50 year 4% state bonds to be deposited with the Treasurer of United States, upon which collateral the Secretary of Treasury would offer for popular subscription, at not less than par, $200,000,000 of 3% Federal bonds, and from the money obtained from sale of latter pay for the state bonds. The 1% made by the government on this investment would be placed at compound interest, accumulating in an amount equal to the principal of the bonds in 50 years, thus enabling the government to return the state bonds "cancelled" at the end of that period. But, herein arises

the question, are we justified in imposing upon future generations a large bonded indebtedness for roads and other improvements that will be worn out, and from which they will derive little or no benefit. It seems that scarcely time enough has elapsed since the appropriation of $500,000, which was intended to serve as an acid test for this scheme of Federal aid, to warrant such an expenditure as proposed in the Bourne measure.

The popularity of the new course in highway engineering at Iowa State College is evidenced by the fact that over eighty students are taking work in this course. Many of these students are specializing in highways. Next year the course will be broadened extensively.

Professor T. R. Agg, who has charge of highway engineering work, has already won a place in the hearts of all the engineering students. His methods of presenting the work are efficient and well liked by the students. He is giving a large amount of data, collected from his personal experiences, which will be exceedingly valuable for future reference. The purposes of the highway engineering course are clearly outlined by Prof. Agg in his article in this number.

The Cedar Rapids Republican has indeed voiced the sentiment of the majority in a recent editorial regarding the high worth and usefulness of our new engineering extension work.

"The college at Ames has been gratified with nothing recently so much as with the active co-operation offered in many of the cities in the developing of extension courses in mechanics and engineering. At Ames they speak especially high of the co-operation which they secured in Cedar Rapids, where a triangular interest was manifested. The manufacturers, the labor unions and the schools are all interested and alike interested. As a result of such co-operation it is predicted many more young men will become qualified mechanics and constructors.

"One of the drawbacks that Iowa cities have offered to manufacturing in certain lines is the lack of experienced and skilled workmen. Many factories intending to locate in Iowa had this

matter up for consideration. It is believed that these extension schools will help to overcome these difficulties now in the way of manufacturing in Iowa, that is manufacturing along the higher skilled and mechanical lines. We believe that the Ames extension department of engineering will prove to be one of the greatest blessings to the state in its aspirations for development along industrial lines."

College Notes

Ames was represented by four men on the program of the Association of the Engineering Divisions of Land Grant Colleges, held last month in Washington, D. C. President Pearson, Prof. J. B. Davidson, and C. S. Nichols, all delivered formal addresses, while Dean Marston, who acted as secretary of the association, took part in several of the discussions.

Dean Marston was honored by being made president for the coming year. The association was organized last February. Thirty-three states were represented at the recent meeting. The work of the organization has prospered, and it promises to be an important factor in outlining the future growth of engineering in land grant colleges.

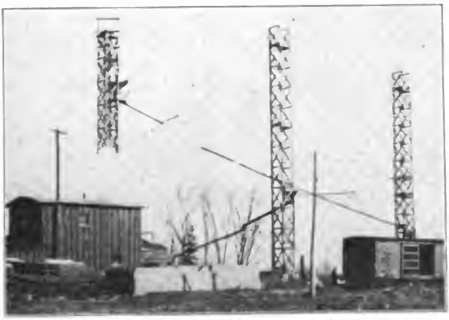
Several interesting talks on engineering subjects have been given recently under the auspices of the various engineering societies. On November 20, G. P. Dieckmann, representing the Northwestern States Portland Cement Co. of Mason City, addressed the C. E. Society on "The Modern Manufacture of Portland Cement." His talk was well illustrated, and clearly detailed all of the steps in the manufacture of Portland cement.

During the same week, E. E. Kellenberger, supervisor of signals on the Western Iowa Division of the Northwestern, at Boone, addressed the A. I. E. E. Society on various feature of automatic signals for steam railways. His address was also illustrated by slides.

On December 4, H. H. Norris and D. R. Scholes addressed the members of the Engineering Society. Mr. Norris, who is associ-

ate editor of the Electrical World, and formerly Professor of Electrical Engineering at Cornell University, was to have spoken the night before to the A. I. E. E., but he failed to arrive in time, so he and Mr. Scholes both spoke to the Engineering Society. Mr. Scholes is chief engineer of the Aermotor Co. of Chicago, and talked on the subject of the design of steel transmission towers. Mr. Norris gave a short talk on the relations that exist between employers and technical school graduates.

The concrete mixing and distributing plant at the new chemistry building is a good example of a large modern plant. Only once from the time the material is unloaded from the cars until it takes its place in the building as concrete does it have to be handled by manual labor. A grab bucket and derrick are arranged to



A View showing the Hoisting Towers and Steel Chutes used for distrubuting Concrete In the Construction of New Chemistry Hall

unload the crushed rock and sand and place it in the storage bins. These are so designed that the material will flow from them by gravity. It is measured in wheelbarrows and wheeled about six feet to the mixer. The space under the bins is utilized for storing the cement, and it has the advantage of being both dry and convenient to the mixer. From the mixer the concrete is hoisted about seventy-five feet high and automatically dumped

into a sheet steel spout from which it gravitates to any part of the building. There are three distributing towers, each of which serves a radius of about seventy-five feet.

The mixer used has a capacity of a cubic yard every 90 seconds.

The first cost of such an installation is quite large, but this is soon outweighed by the saving in time and labor on a job of any size.

A casting weighing nearly half a ton, and poured in the College foundry, is being finished in the machine shop. It is to serve as a base for the gas producer in the new mechanical engineering laboratory. One interesting feature of the work of machining the piece is the fact that, while the milling machine table is only twelve inches wide, the casting is forty-four inches in diameter, so a device had to be arranged to take care of the great overhang. It was suspended from a counterpoised steel cable system, carried on heavy timber framework, so as to move up and down with great ease. By this ingenious arrangement a casting of much larger dimensions could be finished up on a comparatively light milling machine. It is of interest in connection with this to note that the above milling machine was built by J. E. Kearney, B. M. E. '93, of the Kearney and Treckner Co., West Allis, Wis. The first casting made was so hard that the tools used would hardly touch it, and it was finally cracked, during the finishing operation. A new one has been poured and it is hoped that better results will be met with.

Two highway bridges of standard design are being built at the Iowa State College for experimental purposes by the Good Roads Section of the Engineering Experiment Station. One of them will be of solid concrete slab construction, while the other will be of I-beam design with different kinds of flooring. It will first be tested with a wood plank floor with various coverings of earth, gravel, etc., and then a concrete floor will be laid.

The purpose of the tests is to determine the deflections of the bridges under both concentrated and distributed loads, and from these observations arrive at a rational basis for the design of bridge floor slabs. The formulas now in use are largely empirical,

and it is thought that more material is being put into the floors than is necessary.

Professor T. R. Agg of the engineering faculty is in charge of the work. He will be assisted in taking the deflection by Messrs. C. S. Nichols, E. F. Kelley and C. B. McCullough. The results of the tests will be published in bulletin form.

Beginning with December the Highway Commission will issue a monthly bulletin. The purpose of the publication is to present to the people of the state and to others interested in highway work the facts in regard to the work of the county engineers, the county supervisors, and the Highway Commission itself. It will contain costs of materials and will describe methods of doing road work under different conditions. It will also describe any money saving methods, and will serve as a reference for contractors and others engaged in highway construction. Interpretations of the road law by the attorney general will also be given from time to time. The Highway Commission, being the head of the highway work for the whole state, is in a very advantageous position for collecting and publishing such material.

Alumni Notes

H. C. Smith, E. E. '09, is with the Iowa Telephone Co. at Muscatine. Mr. Smith and his wife attended the Iowa-Ames game at Iowa City on November 15.

H. T. Avery, M. E. '05, is teaching engineering at the Ewing Christian College at Allahabad, India.

J. J. Taylor, C. E. '10, gave up his position in the department of mathematics at the Colorado School of Mines at Golden, at the beginning of the school year, to accept a position as instructor in mechanical engineering. He spent the summer in charge of topographical work in the southern part of the state under the direction of the State Geological Survey.

Irvin Hansen, E. E. '12, who is with the General Electric Co. of Schenectady, N. Y., visited the campus last month.

Adolph Fick, C. E. '13, is with the maintenance of way de-

partment of the C. & N. W. Ry., at Antigo, Wis.

Dewitt P. Olson, C. E. '11, has recently been appointed a member of the Boise-Yellowstone Highway Commission and will have full charge of all its engineering work.

D. B. Stonfer, M. E. '08, wife and little daugter of Council Bluffs were home-coming guests of their sister, Miss Lucy Kimball, a student in the Home Economics Division. Mrs. Stoufer, formerly Miss Florence Kimball, is the only lady that has been graduated from the course in mechanical engineering.

C. E. Wright, C. E. '11, has been kept busy in his work as county engineer of Shelby County, replacing the seventy-five or more bridges that were taken out by the high water of last spring.

F. M. Sloane, C. E. '06, is with the C., M. & St. P. Ry. at Ortonville, Minn. He is general concrete foreman of their double track construction on the H. & D. division.

M. E. Packman, E. E. '09, is with the Valparaiso School of Telegraphy at Valparaiso, Indiana.

John S. Dodds, C. E. '12, has recently been appointed engineer in charge of the educational division of the Iowa Highway Commission. He is at present the only member of this division but in the near future there is a promise of more extensive development in that division.

E. C. Peterson, E. E. '04, is district manager for the Northern Electric and Mfg. Co., at Montreal, Canada.

Robt. McCormick, C. E. '10, who has been with the city engineering force of Boone almost continually since graduation, is now located at Des Moines. He is with his father who is in the blank order book and bookkeeping system business.

H. A. Sayre, M. E. '07, is treasurer of the Eagle Coal Co. at Des Moines, Iowa.

John E. Myers, C. E. '10, is surveyor for the Bureau of Lands at Manila, P. I.

E. P. Spaulding, E. E. '04, who was on the Pacific coast for several years, is now located at Sioux City, Iowa.

S. L. Pomeroy, C. E. '12, who was with the Oregon-Washington R. R. and Navigation Co., at Vale, Oregon, is now located at Folk, Idaho.

E. Floyd Shields, Min. E. ex'10, was married to Miss Mabel Prichard at Deer Lodge, Montana, Oct. 18. Mr. Shields is chief

engineer of a large mining company at Butte, Mont.

Clinton B. Wise, C. E. '04, is with the Rock Island Ry. Co. at Des Moines, Iowa.

C. W. Clements, M. E. '06, is a fire and material inspector for the C., B. & Q. Ry., with headquarters at Batavia, Ill. The nature of his work necessitates his traveling back and forth through the states of Wyoming, Nebraska, Iowa, Missouri and Illinois.

S. W. Ware, C. E. '09, is on the dredge "Washington" which is dredging a ship channel from the ocean to Houston. Victor Slater, C. E. '11, is also on this dredge.

George Tinsley, M. E. '06, who for the past year has been in Spain in charge of construction work for the Ebro Construction Co. of New York, has returned to the United States. Mr. Tinsley will not return to Spain but will probably go into business for himself in Nebraska.

Paul Clapp, E. E. '13, who is with the Western Electric Co. at Chicago, is teaching a group of the workers in elementary electricity in one of their evening classes.

C. M. Hewitt, M. E. '09, is with the Colby Motor Car Co. at Mason City, Iowa. He has a little daughter at his home.

C. M. McCormick, E. E. '07, who has been in Chicago for several years is now located at Boulder, Colo.

O. J. Leefers, C. E. '05, is now located at Cedar Rapids, Iowa, where he is engaged in engineering work. He has spent the greater part of his time since graduation in the West.

Paul Wylie, C. E. '11, is county engineer of Guthrie County, Iowa. His headquarters are at Guthrie Center.

C. J. Johnson, E. E. '08, is now located at Erie, Penn., as district manager of the Bell Telephone Co. of Pennsylvania.

"Mike" Adams, C. E. '10, is on the dredge "George W. Catt" in Galveston bay, Texas.

G. J. Adanson, C. E. '05, assistant engineer on the Union Pacific Ry., recently returned to Omaha after a summer's work in Wyoming. He and his wife, formerly Helen Prouty (Sc.), are rejoicing over the arrival of a little daughter in their home.

Otto Watter, E. E. '10, has returned from the Canal Zone and is again located at Waukon, Iowa.

H. C. Beckman, C. E. '12, is now in the office of the chief engineer of the C. & N. W. Ry. in Chicago.

E. G. Amesbury, C. E. '12, is on bridge erection work for the American Bridge Co., at Buffalo, N. Y.

C. E. Shipman, C. E. '04, is located at Billings, Mont. He makes a specialty of irrigation, water works, sewers and drainage surveys.

OBITUARY

Alfred Williams B. C. E. '84, died November 13th at his home in Seattle, Wash., from the effects of an operation for stomach trouble. After graduation he started in as a chainman on maintenance of way, later was appointed U. S. deputy of mineral survey at Cripple Creek. He went to Alaska in '98, serving as engineer in charge of building the White Pass and Yukon railroad, being placed in charge of the first division of road after its completion. The years '02 to '09 found him engaged in mining practice, and in charge of the construction of two mine railroads, then he went to California as president of the Ocean Shore Ry. Co. "which reaches all the beaches," San Francisco, which position he held at the time of his death. His is a successful career and a place that will be hard to fill.

THE IOWA ENGINEER

CONTENTS

PUBLISHED MONTHLY DURING THE
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STUDENTS OF THE DIVISION OF ENGINEERING
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Engineering Vision

"And laok that thou make them after the pattern that was shown thee in the mount."

THESE were the words spoken to Moses when he was ordered to build a tabernacle unto the Lord. Every engineer must have his vision. His plans must spring from an inspired intelligence. His patterns must be formed with wisdom by a mind of keenest imagination

Morse saw the vision of a method of instantaneous communication and gave us the telegraph. Bell imagined that the transmission of the human voice over long distances was possible and the result was the telephone. Langely imagined that he could fly as a bird and thence came the air-craft. Edison conceived the possibility of recording sound and we are now able to hear the voice of the absent. Cooper saw a violent torrent harnessed and serving humanity and he gave us the Keokuk dam. Goethals, defying most stubborn obstacles, followed a clear vision and the result is the culminating wonder of an age of engineering, the Panama canal.

Every human vision is preceeded by a period of preparation and fasting. Student days are days of preparation. Are you preparing for your vision?

—R. B. DALE

VOL. XIV. JANUARY, 1914 NO. 4.

The New Steam and Gas Laboratory at Iowa State College

M. P. CLEGHORN, M. E. '07*

The Department of Mechanical Engineering has waited long and patiently for the time to come when sufficient equipment, and a suitable building for housing that equipment, would be available for the teaching of Steam and Gas Engineering as it should be taught in an institution of this kind. The department was handicapped on every side in its endeavor to meet the needs along these lines. While some of the quipment had been purchased recently and represented the best in type and construction, the remainder was old and worn and somewhat out of date. It was scattered throughout several buildings and in many cases had to be moved from place to place each year to make room for other things.

Those in touch with the situation and knowing the needs in this direction have worked long and tirelessly for something better, and at last it is in sight and every one is rejoicing over this success. The efforts have resulted in a new Steam and Gas Engineering Laboratory which will have an equipment for experimental work only second to none in the country.

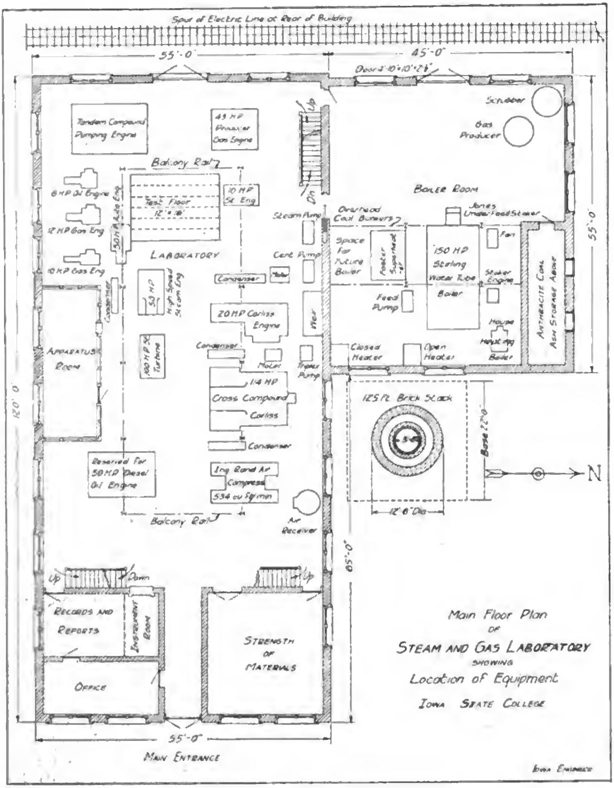
*Associate Professor of Mechanical Engineering, Iowa State College

Last winter an appropriation of $50,000.00 was made for the building, and special appropriations of about $13,000.00 for new equipment. The contract was let to Mr. C. E. Heaps of Davenport, Iowa, for $39,700.00. The old power plant which the older engineering alumni will remember with kindly thoughts was wrecked to make room for this, its worthy successor.

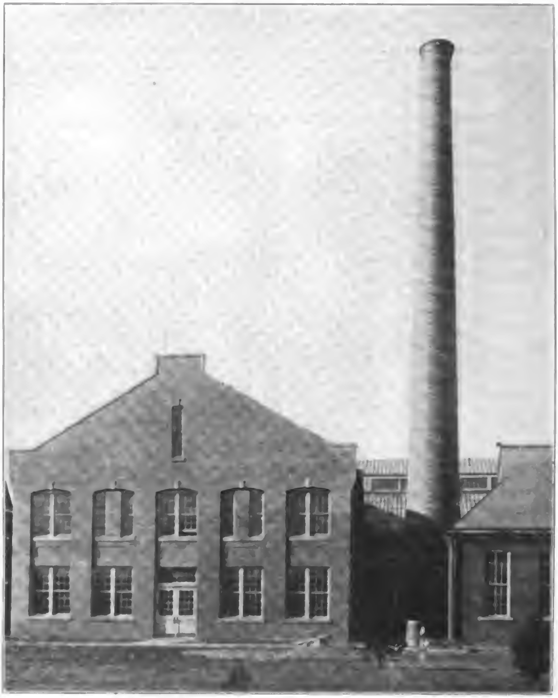
The new building is in the shape of an L with the main part extending east and west between the old engineering hall and the foundry and facing the east. It is 55 by 120 ft. The wing is 55 by 45 ft. and extends north back of the foundry. The building is built of hard burned brick and has a steel and Federal tile roof and is fire-proof throughout. The east 24 ft. of the building proper is full two stories high. This part has a basement containing toilet and locker room, and a store room. The first floor contains two offices and instrument rooms, a materials testing room, and a front hall leading to the main engine room. On the second floor of this portion of the building will be found two report rooms and a lecture room. Each room is equipped with blackboards, and the report rooms with oak tables and chairs besides other necessary equipment.

The remainder of the building is of the one story and balcony type with monitor roof for admitting light and air.

The main engine room is 55x96 feet. Near the center and at the south side is located a tool and instrument room. The equipment on this floor includes a 10x20x24 Cross Compound Corliss Engine of the rolling mill type capable of developing 114 indicated h. p. at 125 revolutions per minute. It will have its own condenser, and be equipped with steam jackets and special devices for carrying on a great variety of experimental tests. Next to this is an Ingersoll Rand Cross Compound Two Stage air compressor with 12x18x14 steam cylinders and 16x10x14 air cylinders and capable of compressing 534 cubic feet of free air per minute. This will also have its own condenser and be arranged for special tests. In the same group and in line with the above engines may be seen a 20 h. p. Corliss engine. This engine is equipped with the old fashioned "crab claw" valve gear and is of considerable interest in that respect, but it is well preserved and well adapted to student use. The student will also have at his disposal a 12 horse power, and a 50 h. p.



Main Floor Plan of Steam and Gas Laboratory showing Location of Equipment
Iowa State College



The New Steam and Gas Labratory at Iowa State College

high speed steam engine and a 100 h. p. steam turbine. All of these steam engines are located as shown on the plans so as to be in close proximity to the pipe tunnel carrying the main steam and exhaust pipes.

The gas producer power plant should not be overlooked. It is composed of a 50 h. p. Fairbanks Morse Suction Gas Producer connected to a 43 horse power two cylinder vertical gas engine

built by the same company. The plant uses hard coal or coke and the engine is equipped with indicators, brake, speed countters, gas sampling connections, etc.

To the south side of the room are located the 12 h. p. Olds gasoline engine, the 10 h. p. Otto gasoline engine, the 6 h. p. Mietz and Weise oil engine, and the 50 h. p. 4 cylinder automobile engine. A 50 h. p. Diesel Crude Oil Engine will be noticed on the plans. This has not been purchased as yet but the space is reserved for this and it will be obtained as soon as possible.

Pumps of various types both rotary and reciprocating are located along the north wall of the engine room and in close proximity to a large weir where the water from them may be measured. This weir may also be used for measuring the circulating water from the various condensers. This water may be returned to the storage tanks in the boiler room basement if desired. The tandem compound pumping engine having a rated capacity of 5,000 gals. per hr. is located over the 2,250 foot well. This is to be overhauled and will be splendid equipment for pumping tests and for determining cost of pumping water with this type of pump.

A test floor 12x16 feet built of steel beams set in concrete is located to the west end of the main floor and directly in front of the large outside door, and arranged for the bolting of machines to it for testing. This will be appreciated when machines are sent in to the Department for testing and are not to remain a sufficient time to demand a foundation of their own. This floor is to be supplied, with saturated and superheated steam, and with water. At this point it may be well to call attention to the arrangement around this floor. As is seen on the plan the 43 h. p. Producer Gas Engine, the 10 h. p. Steam Engine, the 50 h. p. Steam Engine, the 6 h. p. Mietz and Weise Oil Engine, the 12 h. p. Olds Gasoline Engine and the 50 h. p. Automobile Engine are arranged in such a way that any one may be belted to machines on this test floor.

All steam, water, gas and air pipes and electric wiring are carried in the large 5x10 tunnel which extends through the center of the building. Here are located the main headers for saturated and superheated steam, and exhaust, with all cross

connections and valves easily accessible and making the equipment very elastic. Goose necks of long radius bends extend from the tunnel to the engines above. Very little piping will show above the floor. Small tunnels 21x30 inches in section are located where needed to supply the engines not adjacent to the large tunnel. The main floor is well supplied with floor drains to take care of drip water from brakes, condensers, etc.

Two glass inclosed rooms on the balcony of this engine room will be used for coal and gas analysis and for instruments. The remainder of the balcony will be used for the small gas and gasoline engines, hot air engine, fan blower, refrigeration machine, water wheels, injectors of various types, gauge and indicator calibrating devices, all fitted up for testing, and other small apparatus that enters into the complete equipment of such a laboratory.

The north wing contains the gas and steam generating equipment. A 150 h. p. Sterling water tube boiler has been installed which was designed for a working pressure of 250 pounds per sq. inch. This is equipped with a Jones Under Feed Mechanical Stoker. To overcome the difficulty experienced with this type of stoker in the removal of the ashes the Department of Mechanical Engineering has designed a special dumping grate which it is hoped will at least partly solve the problem. The ashes will be dumped into a bucket conveyor and elevated to an ash bunker where it may be spouted to wagons outside. Over the boiler are located the coal bunkers and the conveyor, which is arranged for handling both the coal and ashes. From the bunkers the coal will gravitate through downspouts to the stokers.

Adjacent to the boiler stands the Foster separately fired superheater capable of heating the steam to 600 degrees F. The gas producer mentioned above stands in one corner of the boiler room and near to the coal storage. Space is also reserved for the addition of another boiler in the future as occasion demands it.

In the basement below are three large water proofed tanks equipped with weirs and holding 50,000 gals. of water for boiler feed or for pumping experiments.

The chimney for the boilers is 125 feet high and has an inside diameter of 44 inches. This is built of radial brick and connected to the boilers by means of an underground smoke duct.

Specifications and Tests for Drain Tile

R. W. CRUM, '07*

Tile Drainage is of very great importance in Iowa. The state leads all others in the production of drain tile. In the year 1910 more than $3,000,000 worth of clay tile were made and it was estimated that more than $1,000,000 of cement tile were made, and since 1910 the industry has been constantly growing. More hollow clay products are made at Mason City than at any other place in the world.

In 1911 it was estimated that over 125,000 miles of tile drains have already been laid upon Iowa farms and that to complete the public and private drainage systems in the state will require the ultimate expenditure of $450,000,000. Large tile drains are being used more and more today, instead of the large and wasteful open ditches common in the past. The present and future saving of valuable agricultural land by using tile instead of open ditches, will eventually pay the additional first cost of the tile drains.

It has been the increasing use of and consequent large outlay for tile larger than 15 inches in diameter that has forcibly brought home to us the need of assurance that these tile be strong enough to support the load that will come upon them, and that the money so spent will not be wasted. The failure of a single tile will clog up a drain and is certainly a serious matter, involving not only the cost of taking up and relaying the tile (a costly process when the broken tile is not readily found) but a possible loss of a crop.

In view of these facts, upon examining the long list of cracked and collapsed tile compiled by the Engineering Experiment Station, we are impressed with the seriousness of the situation and the imperative need of making sure that these large tile are strong enough.

For the smaller sizes, experience over a long term of years has probably determined the necessary strength of the tile, but in the larger sizes we have no experience to guide us, and since the failure of only one tile is so costly and serious in its conse-

*Assistant Professor of Civil Engineering, Iowa State College

quences, we cannot afford to wait for experience to guide us, but must go ahead and develop the necessary requirements for safety by experimentation and theory. The specifications for drain tile, and standard methods of testing as recommended by the Iowa Engineering Experiment Station are the outcome of a patient study of the theory and very many practical experiments.

As a starting point it was necessary to know the weight that would come upon a tile from the filling of the ditch. Before attempting to figure out this load it was necessary to know the manner in which the load would come upon the tile. By a study of a number of typical tile drains it was found that under ordinary back filling, the top and bottom one-fourth of the tile had to bear the load.

In very few cases do the tile touch the side wall of the ditch after back filling. It was later found that even careful tamping around the sides, would have very little effect on the cracking of the tile. It would, however, have some effect upon the collapse of the tile.

From a careful study of the mathematical theory governing the case, Professor Marston worked out a formula by the solution of which the load on a pipe at a given depth could be determined. This formula is expressed thus:

W equals C w B^2, where W equals total load on pipe per unit of length, w equals wt. of ditch filling per cubic unit. B equals the breadth of ditch a little below the top of the pipe, and C is co-efficient depending upon the height and breadth of the ditch, the ratio of lateral to vertical earth pressure, and the co-efficient of friction of the material in the ditch. It was necessary to find the values of the co-efficients of friction and ratio of lateral to vertical pressure, experimentally, since these figures depend upon the character of the soil through which the ditch runs. These values were determined experimentally for a number of different soils, common to Iowa. A table giving safe values of the load on pipes in ditches, for different depths and different ditch filling materials is given in Bulletin 31 of the Iowa Engineering Experiment Station. Also a table of values of C to use with other depths than those given. With other soil conditions it would be necessary to make some experiments and figure a value of C, as is demonstrated in the same Bulletin.

Testing a Thirty-Six Inch Drain Tile with the Ames Senior Testing Machine

An engineer should have no trouble in arriving at the value of C for any particular case not covered by the experiments made at the College.

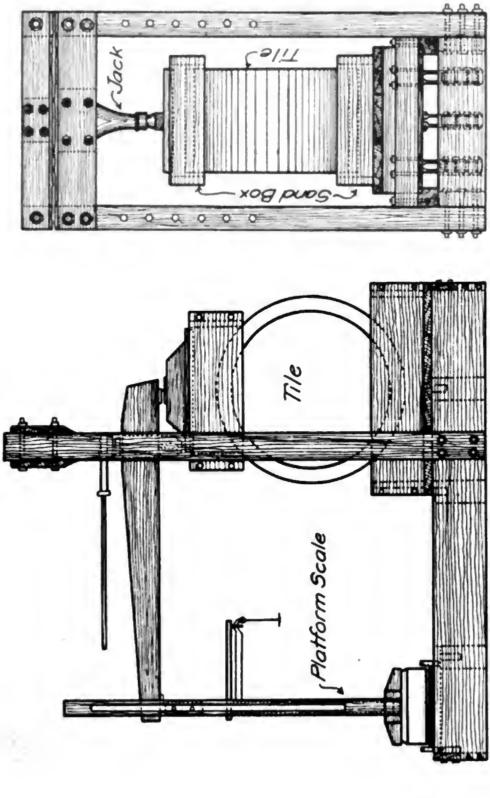
The value of the co-efficient C in the formula was found to increase with the depth but at a constantly decreasing rate, and that when the depth became approximately 10 times the breadth of the ditch, C became constant, and since the other factors are

constants, no greater load will come on the pipe than the load due to a depth equal to about 10 times the breadth.

In engineering work such as this there are always a number of uncertain and variable elements present, and a mathematical theory is only valuable when based upon correct experimental data. It was then necessary to actually measure the load coming upon some pipes in actual ditches to ascertain if the formula gave a correct value for the load. This was done by weighing the load on several lengths of tile in a ditch at varying depths down to 24 feet. A remarkable concurrence between the actual loads and the loads figured from the formula was found. In consequence, we have assumed that the formula is correct and that the actual loads on pipes in ditches can be computed therefrom. In addition, the theory is quite closely confirmed by a series of tests made by F. A. Barbour, Boston, Mass., in 1897.

Since there is always variation in the ditch conditions, and in the soil, there will be some variation between the actual and the figured load. It is recommended that in estimating the load to come upon a given tile that the figured load be increased by at least 65% in order to give a necessary margin of safety, to provide for the variation noted, and unexpected loads that may come on the line of tile from above. Undoubtedly, in many cases the factor of safety would need to be larger.

A large number of tile in various parts of the state were found to be cracked after the filling was placed, indicating that the tile were not strong enough to carry the load. Similar tile tested under similar conditions proved this to be true, that the tile were not strong enough to carry the weight of the fill. It is argued that cracked tile seldom collapse. It is true that under ordinary conditions the side filling is close enough to prevent the tile collapsing and that scarcely any load will spread the tile enough for a collapse. A lateral compression of only 1-50th inch will allow the tile to crack. However, it appears almost certain that some day the cracked tile will collapse. Tile drains are not designed to carry the maximum amount of water that is likely to come upon them, since this maximum flood is only to be expected at intervals of several years, and a tile working under pressure will eventually get rid of the water. It will get rid of the water if it is not already cracked. If the tile is



The Ames Senior Testing Machine, for Testing the Strength of Drain Tile and Sewer Pipe

cracked, the water will flow out through the cracks, saturating and softening the surrounding soil, which will allow the pieces to fall, and the drain is ruined for the time.

The Iowa method of testing tile was developed partly for the purpose of finding out if it was lack of strength that had caused cracking of so many tile. The result of testing a large number of tile established this to be the case, as noted above. This method of testing, which may be considered standard for Iowa, very closely approximates the ditch conditions, and gives substantially the same loading as the actual fill on a tile in a ditch.

Knowing the maximum load which a line of tile will be called upon to bear, all that is necessary to make a safe and reliable drain is to specify the maximum load that the tile must stand, using a factor of safety of at least 1.65 as mentioned above, and then to make certain that tile having the strength specified are delivered upon the job.

In order to make sure of the latter condition, it is necessary that every tile on the ditch be inspected, for condition and dimensions, and that enough tile be actually tested by loading to destruction, to establish the average strength and uniformity of the shipment.

Indeed it would be a good thing if all the tile could be tested, not to destruction, but to prove that they would all carry the load to come upon them in the ditch. No machine light enough and convenient enough for doing this has been developed, but some of the experts interested are working upon such a machine.

As to the actual method of testing the tile, a number of ways have been proposed, and there is considerable debate as to which is the best. The Iowa method, which will be described with the others has been adopted as official by the Iowa State Drainage Association, the Association of Iowa Brick and Tile Manufacturers, the Iowa Cement Users' Association, and the Iowa Engineering Society.

The most authoritative, and the most widely used specifications for structural materials in the United States are those prepared by the American Society for Testing Materials, a society composed of Users, Manufacturers and Industrial Experts. This society has a committee, of which Dean Marston

is chairman, which is to report to the Society, Standard Specifications for Drain Tile. When the report of this committee is accepted by the society it will become practically the standard

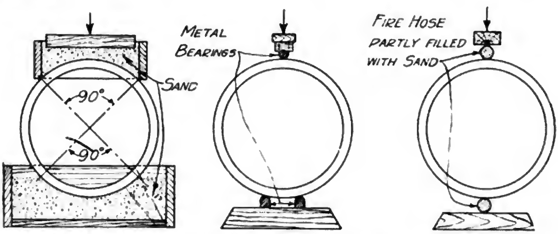
Photograph Showing the very Best Possible Bedding of Pipes in Ditches. The bottom of the ditch has been shaped to fit the 36 in. pipe and the bottom of the pipes bedded in a layer of granular material. The side filling has been carefully tamped around the pipe.

for the United States, and will probably supereede the Iowa Specifications in Iowa.

Since more investigations of drain tile have been made at this college than any other place, and since Iowa is by far more interested than any other state, the investigations of this committee have naturally been centered at Ames.

This committee held a meeting this fall at Ames and Jefferson, Iowa, for the purpose of starting a series of tests upon 300 clay tile and 300 cement tile to aid them in deciding upon a standard method of testing. These tests have since been completed and the Iowa Engineering Experiment Station is engaged in preparing the results obtained, for the use of the committee.

The differences in the methods proposed for testing depend primarily upon the method of applying the load to the tile, and the choice has been narrowed down to three proposed arrangements.



The Three Proposed Methods of Testing Drain Tile and Sewer Pipe

In the Iowa method as proposed by Dean Marston the load is distributed over the top and bottom 90° of the tile by means of sand beds and aproximates very closely the conditions in the ditch.

In the 3 Point method as proposed by Professor Talbot, of the University of Illinois, and Mr. C. W. Boynton, of the Universal Portland Cement Company, the tile is supported at the bottom on two strips about 3 inches apart, and the load is applied to a single strip at the top.

In the Hydraulic Bearing method, as proposed by Mr. Mont

Schuyler, of the City of St. Louis, the load is applied through a hydraulic bearing, consisting of a tube filled with water, with a corresponding support for the tile.

Tests indicate, as well as theory, that there is a constant relation between the strength determined by all three of these methods, and if that proves to be the case, the particular method used will probably depend upon the convenience and adaptability of the different machines. The essential condition is that the test must give a measure of the load the tile will support in the ditch.

The exact method of applying and measuring the load, should not have any effect upon the resulting strength, and the type of machine used should depend upon whether it is to be used permanently in one location or only temporarily. Professor Marston and Professor Talbot have designed homemade machines, which can be easily and cheaply built on the line of any ditch.

In this discussion the absorption test upon pieces of the tile should not be overlooked. The objects to be obtained through limiting the permissible absorption of the material are,—1, To insure that the manufacture is such as to give the best results reasonably possible with the material used,—2, To exclude for certain uses materials from which satisfactory pipe for those uses cannot be produced commercially.

The committee of the American Society for Testing Materials is also studying the allowable absorption and will doubtless make some recommendations to cover this point.

Copies of the specifications recommended by the Iowa Engineering Society and the Standard Specifications for making absorption and strength tests of tile may be secured at the office of the Director of the Engineering Experiment Station.

Standards for Detailing

J. E. BANKS, B. C. E. '89*

STEEL BRIDGE AND BUILDING CONSTRUCTION.

In the year 1900 a number of bridge companies of the United States were consolidated into one, the American Bridge Company.

Each of the companies had, in more or less elaborate form, its "Standards," consisting of instructions for ordering material, description of duplicate parts, directions for designing, and auxiliary tables.

The investigating and assorting of this "Standards" material, and eclectic matter, and its incorporation into an orderly system, was found a task of considerable difficulty and concern.

In 1906 a separate division of the Engineering Department called the "Bureau of Standards" was created; this Bureau was placed in the writer's charge in 1908.

As one of the undertakings of the new Bureau came the preparation and publishing of "Standards for Detailing," a book devoted to the detail draftman's work of design.

There are certain minor portions of the steel structures of bridges and buildings which tend to uniformity in style, such as rivets, turnbuckles, brackets, etc. This uniformity is due in part to likeness to use, and in part to the need of special machines for the making. There is an advantage, also, in being able in slack time to fabricate a stock of these standard pieces.

There are details of some classes of members for which likeness in design is important to be considered, for example, eye bar heads, pin ends, curved ends of girders, etc. Special machinery is needed for these in upsetting, turning and bending.

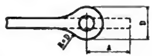
There are also what may be termed typical details, which are meant to serve as guides rather than set forms for designs. These are shown in column bases, lateral connections, etc.

Besides the above there are certain diagrams and mathematical tables useful in design such as "A graphical method for

*Engineer Bureau of Standards, American Bridge Company, Ambridge, Pa.

EYE BARS

ORDINARY EYE BAR



BAR			HEAD				
Width	Thickness Max.	Thickness Min.	Diam. D	Max. Pin Diam.	Excess Head over Bar, per cent.	Add. Material A For ordering Bar	Add. Material A For figuring Weight
2"	1"	¾"	4½"	1½"	37.5	1'- 0"	0'- 7"
			5½	2½		1- 4	0-11
			*6½	3½		1- 9	1- 4
2½	1	¾	6	2½	40.0	1- 3	0-10
			7	3½		1- 7	1- 2
			*8	4½		2- 0	1- 7
3	1½	¾	7½	3½	41.7	1- 6	1- 1
			8½	4½		1-11	1- 5
			*9½	5½		2- 4	1-10
4	1½	¾	10	4½	37.5	1-11	1- 6
		⅞	11	5½		2- 3	1-10
		1	*12	6½		2- 8	2- 2
5	2	¾	12	5½	36.0	2- 1	1- 9
		1	13½	6½		2- 8	2- 2
		1	*15	8½		3- 3	2- 9
6	2	⅞	14	6½	37.5	2- 4	1-10
		1	14½	6½		2- 6	2- 1
		1	*16½	8½		3- 2	2- 8
7	2	*1	16½	7	35.7	2- 7	2- 2
		1⅛	17½	8		2-11	2- 6
		1¼	*18½	9		3- 4	2-11
8	2	1	18	7	37.5	2- 8	2- 3
		1⅛	19	8		3- 0	2- 8
		1¼	*20	9		3- 4	2-11
9	2	1¼	20	7½	38.9	2-11	2- 6
		1¼	22	9½		3- 7	3- 1
10	2	1¼	22½	9	38.0	3- 5	2-10
		1¼	24	10½		3- 9	3- 3
		1½	*25	11½		4- 1	3- 7
12	2	1¼	26½	10	37.5	3- 8	3- 3
		1⅜	28	11½		4- 2	3- 6
		1½	*29½	13		4- 8	4- 1
14	3	1⅝	31	12	35.7	4- 3	3- 9
		1½	33	14		4-10	4- 4
		1¾	*34	15		5- 5	4- 8
16	3	1¾	36	14	37.5	4-11	4- 5
		1¾	*37½	16	34.4	5- 5	4-10

ADJUSTABLE EYE BAR

Minimum length of short end from center of pin to end of screw, 6'-6", preferably 7'-0". Thread on short end to be left hand.

BAR		SCREW END				
Width	Min. thickness	Diam. U	Excess Upset over Bar per cent.	Length M	Add. Material B For ordering Bar	Add. Material B For figuring Weight
2"	*⅝"	1¾"	47.6	4"	1'- 0"	8"
	¾	1⅞	44.0	4½	1- 0	7½
	⅞	2	42.8	4½	0-11	7½
2½	*¾	2⅛	53.8	4½	1- 0	8
	⅞	2¼	46.4	5	1- 0	8
	1	2½	46.4	5	1- 0	7½
3	*⅝	2¼	44.4	5	1- 0	7½
	⅞	2⅜	41.7	5	0-10	7
	1	2½	36.5	5½	1- 1	8½
4	*⅞	2½	36.5	5½	1- 1	8½
	⅞	2¾	44.0	5½	0-11	7½
	1	3	52.1	6	1- 1	8½
	1⅛	3¼	60.8	6½	1- 2	9½
5	*⅞	2¾	48.0	6	1- 0	8
	⅞	3	39.1	6	0-11	7
	1	3¼	44.5	6½	1- 0	8
	1⅛	3½	50.5	7	1- 1	8½
	1¼	3¾	56.9	7	1- 2	9
6	*1	3½	41.1	7	1- 0	7½
	1⅛	3¾	45.8	7	1- 0	8
	1¼	4	50.0	7½	1- 1	8½
	1⅜	4¼	54.9	8	1- 2	9½
7	*1⅛	4	42.8	7½	1- 0	8
	1¼	4¼	46.1	8	1- 1	8½
	1⅜	4½	49.8	8½	1- 2	9
	1½	4¾	53.8	8½	1- 2	9½
8	*1⅛	4¼	42.0	8	1- 0	8
	1¼	4½	44.1	8½	1- 1	8½
	1⅜	4¾	46.6	8½	1- 1	8½
	1½	5	49.8	9	1- 2	9
	1⅝	5¼	53.1	9½	1- 3	10

Bars marked * should only be used when absolutely unavoidable.
Deduct pin hole when figuring weight.

Fig. 1

PLATE GIRDER DIAGRAMS

LOAD UNIFORM

R — Reaction $= \frac{S\,Ad}{2L}$
M — Maximum Moment. $= Ad$
Ma, b, c — Moments.
A_0 — Area of flange angles
A_1 — " " " " and First Cover.
A — Total area of flange $= \frac{M}{Sd}$
$C_{1,2}$ — Required length of Covers.

S — Allowed stress per square inch.
r — Allowed stress on one rivet.
N — No. of rivets req'd in web between end and center $= \frac{M}{rd}$
Nc — " " " " " " " c
Nb — " " " " " " " b
Na — " " " " " " " a

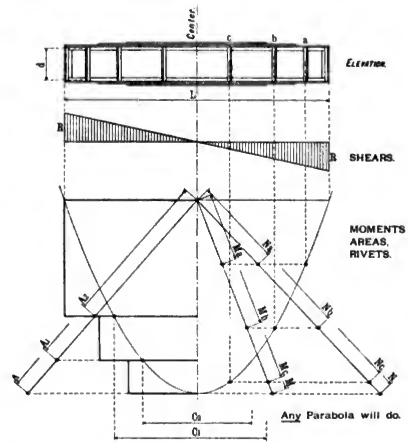


Fig. 2

BEAM CONNECTION ANGLES

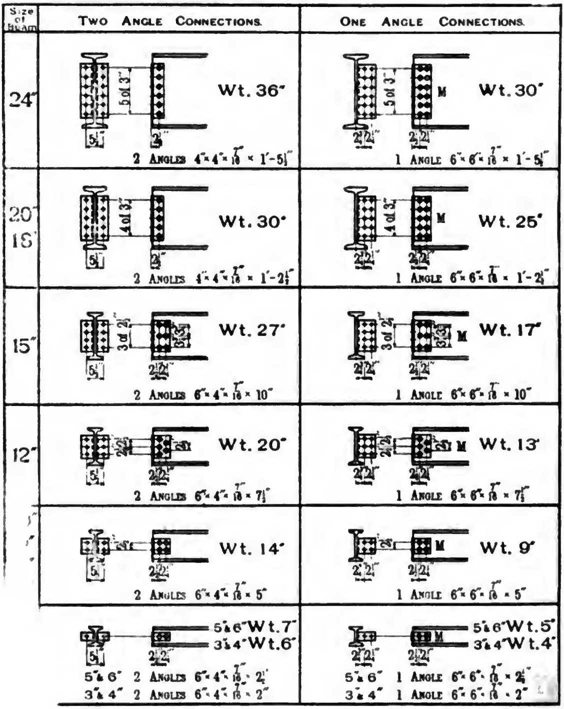


Fig. 3.

determining the length of girder cover plates," and metric conversion tables.

As an illustration of the development of a "standard detail" consider the heads of Eye Bars. These were formerly made oblong, as conforming to theory; but are now made circular, as a result of test and practice. The present proportions of

head have been determined as guided by many years' tests and trial, adding material here, reducing there, as results seemed to warrant. Tensile tests were made upon eye bars built to full size, such as go into the structure.

Fig. 1 is a copy of page 95, Standard details for Eye Bars, plain and adjustable. Note in particular the additional section through the head; and the increased diameter for the upset.

Fig. 2, page 55 of Standards for Detailing, shows a Plate Girder Diagram for uniform load, indicating area and length of cover plate, and rivet spacing.

Fig. 3 is a copy of page 145, Beam Connection Angles. These are found to cover usual range of practice in Office Building construction. The 5½ inch constant dimension between lines of field rivet holes for connection has proved a valuable feature. The difference in connection angle gauge is more than made up by the uniformity in spacing.

For such diagrams and corresponding analytic work the theoretical explanation is not given. This can be had by reference to text books.

Throughout the book the endeavor has been to present to the Engineer and Draftman the information needed for efficient and economic design.

Iowa Coal for Iowans

C. L. MINIS '15

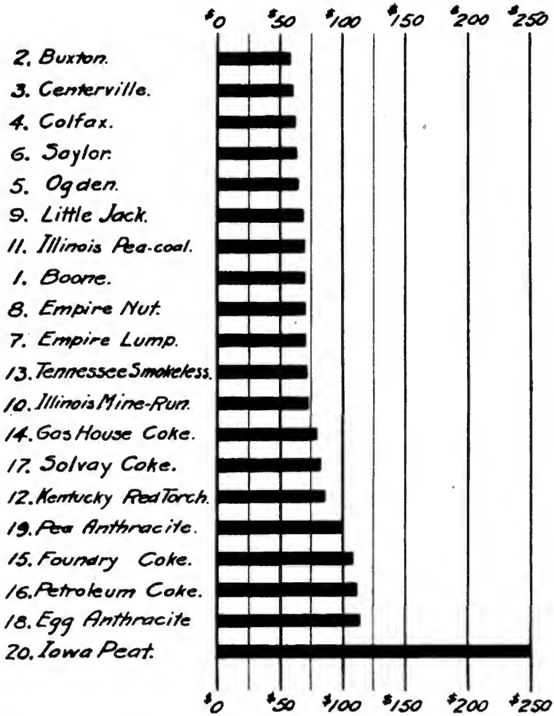
Six and a half million dollars are spent each year by Iowans to heat their homes, while untold millions more are poured out to heat offices, stores and factory buildings. Yet until the recent series of exhaustive tests carried on by W. H. Meeker and H. W. Wagner of the Iowa Engineering Experiment Station, there has been no data to guide Iowa coal users in their selection of heating and power producing coals. That Iowa can cut down its coal bill is shown by these careful tests and investigations. The fact that Iowa coals can be burned with a saving of 8% over Illinois coals and from 26% to 65% over Eastern coals is the result of the inquiry extending over twenty of the popular coals used in Iowa.

Within a fifty mile radius of the central Iowa mines, Iowa soft coal is cheaper both in cost per ton and evaporative cost than any other fuel. To heat an eight room house costs on an average of $65 a season (five months) with Iowa soft coal, $70 with Illinois coals and from $80 to $107 with Eastern coals from the soft coals to the more expensive cokes and anthracite. Eastern fuels are, in fact, cheaper in cost per ton and evaporative cost at the mine than Iowa fuels. The long haul is responsible for the increased cost to the consumer of Eastern coals—a factor which can never be materially reduced. Iowa peat, as mined, exists without a friend when its true cost is known, since $250 is the average cost per season for heating the above eight room house.

With the small consumer other factors than cost may decide his choice. The general question of cleanliness in the boiler room as well as through the whole house is important. Iowa coals run especially high in ash and gaseous matter. Sulphur fumes and other gases are given off in large quantities from Hawkeye fuels. Illinois coals are cleaner to handle than most Iowa coals, although the gases given off are approximately the same. Eastern fuels have the lowest amount of dust present. The smoke and soot nuisance is greatest in Iowa coals, less in Illinois coals and practically nil in Eastern fuels.

Not only the cleanliness of a coal but the attention required in its use is a deciding factor for the small user. The time of kindling an Iowa coal is much less than for Eastern fuels. Kentucky Red Torch is the quickest in this respect. In some cases fuels should be chosen, one charge of which will give a nearly constant heat without attention over a long period of time. It was found that the approximate life of a full charge of Iowa coal is from seven to eight hours, about the same time for Illinois coals, while Eastern coals hold fire for from eight to fifteen hours. More frequent poking and leveling are required of all soft coals since the life of the charge is much less than for cokes or anthracites.

The above fuels form clinkers in the same ratio in which ash is found; i. e., Iowa coals run high in clinkers (with the exception of Centerville coal which is very low), Illinois fuels low. and Eastern fuels are practically without clinkers.



Season costs with Fuels Tested. Each heavy horizontal line represents a fuel cost derived from the averages of all tests on that fuel according to the calculations explained in Art. II, Bulletin 33.

One of the conclusions drawn from the investigation is that it would be desirable in many cases of house heating to have on hand a variety of fuels. By this scheme one would use Kentucky Red Torch for building up the fire, a cheap Iowa coal during the day and bank the fire at night or other periods when

it is not given attention, with Tennessee Smokeless or anthracite.

The evaporative cost is most important to the large consumer of coal. Extremely careful tests placed the cost of evaporating 1,000 pounds of water (from and at 212° F.) at \$.374 for Iowa soft coals, \$.406 for Illinois coals, \$.471 to \$.618

Photrgraphic View of Boiler Set up for Operation at Ames.

for Eastern coals (including anthracite) and the prohibitive \$1.441 for Iowa peat. This places Iowa soft coals in a position without competition from foreign fuels. The ash content of the fuel is also of importance to the large consumer. Iowa coals tested ran from 6% to 12% ash, the Eastern coals are

from 2% to 13% ash, with the average in favor of this class of fuels rather than Iowa coals. Illinois Mine Run is over 16% ash, the highest per cent of any fuel tested (except Iowa peat), while Kentucky Red Torch is only 3.3% ash, the lowest in ash content with the exception of Petrolium coke which is approximately 2%.

Twenty different fuels were tested upon which thirty-eight general efficiency and eleven special efficiency tests were carried out. The six Iowa coals tested are representative of central and south central Iowa soft coals. From the standpoint of cost it was found that the dirty, sooty Iowa soft coal has the victory of supremacy over the more popular coals.

A steam house heating boiler of the vertical sectional type located in the basement of the Mechanical Laboratory of the Iowa State College was used in these tests. The complete tabulated data upon this experiment, with results and conclusions, is presented in Bulletin No. 33 on "House Heating Fuel Tests."

EXPERIMENTAL ROAD BUILDING BY THE DEPARTMENT OF AGRICULTURE.

Over four hundred and eighty thousand square yards of different types of roads for experimental and object lesson purposes were constructed during the fiscal year 1912-1913 under the supervision of the Office of Public Roads, U. S. Department of Agriculture, according to Bulletin 53 of the Department, making a total of over four million square yards of road constructed under the supervision of this Office since 1905.

The types of roads built were brick, concrete, oil-cement concrete, bituminous concrete, bituminous-surfaced concrete, bituminous macadam, surface treatment, macadam, asphalt-slag, oil-asphalt-gravel, oil-gravel, oil-coralline, gravel-macadam, gravel, slag, sand-clay, sand-gumbo, burnt-clay, shell, and earth. The object lesson and experimental work during the past year was done at a cost to the local communities of $139,841.89. This does not include the salaries and expenses of the Department engineers.

The road work during the year was done in Arkansas, Florida, Georgia, Kentucky, Maryland, Mississippi, Nebraska, North Carolina, South Dakota, Tennessee, Texas, Virginia, Wisconsin,

A New Book For Machine Designers

In November of 1913 the McGraw-Hill Book Co. published a Hand Book for Machine Designers and Draftsmen, by Frederick A. Halsey, editor emeritus of the American Machinist and associate in mechanical engineering, Columbia University. The book has the unique feature of being a collection of methods, data and basic facts specially applicable in machine design. These collections were taken from technical journals and from other sources such as the transactions of engineering societies. In describing this feature we might well quote a paragraph from the author's preface,—"as an editor the author's heart has often ached at the manner in which contributions to technical journals of permanent value and usefulness form a procession to the limbo of forgotten things and benefit none but those under whose eyes they happen to fall at the date of publication. This volume is primarily an effort to rescue from the oblivion of the out of print such contributions as are of direct use in the design of machinery." Mr. Halsey's broad experience well qualifies him as a collector of such material and the arranging of it in a manner most suitable to machine designers and draftsmen.

The book is profuse in drawings which clearly illustrate the things that are essential to the designer, while the collection of diagrams and charts is the most nearly complete of any book published along this line. The size of the hand book, 8½x11", is especially suitable for draftsmen as it lies open at any page, and the large size sheets make the diagrams and charts more readable.

It is the intention of the author and publishers to add new material to the work from time to time for the purpose of keeping it continuously up-to-date. These additions are to be first published in the American Machinist and one can keep his copy up-to-date by following this publication.

Engineering Extension Activities

J. W. PARRY*

The Iowa State College through its newly organized department of Engineering Extension has introduced for the service of the citizens of the state two new lines of effort during the month of January.

The first took the form of a Short Course of Instruction for Painters and Decorators, the second the Automobile Institute.

From January 6th to 9th there was held at the college what is believed to be the first Short Course of instruction in the trades undertaken by a state technical institution. The course for Painters and Decorators given included instrnetion in the graining of woods, in the stenciling and blending of walls, and some instruction in sign writing. The response met with was far beyond expectation, preparation being made for thirty students and the registration running to fifty-eight. The Painters and Decorators of not only the state of Iowa but all over the country have never had an opportunity to secure any formal instruction of any kind and were eager for just the kind of information which the Short Course provided. It has always been the case, if a man wanted to be a painter, he bought a paint brush and a gallon of paint and borrowed a step ladder, and he was a painter. The correct way of doing things in this craft has never been worked out, and the trade has been largely one of tricks. Considering the fact that over Ten Million Dollars a year is spent in interior finishing and decoration of private and public buildings, instruction in this branch of the building trade is of great economic importance.

The course of instruction was given at the request of the Iowa Association of Master Painters and Decorators, which appointed a special committee, composed of Mr. F. M. Michael of Waterloo, Mr. J. S. Dogett of Ames, and Mr. George Ellerd of Sioux City. This committee arranged for a convention to be held at Ames, January 5th and 6th, which thoroughly went into the matter of training for the trades, pointing out that the time

*Assistant Professor, Engineering Extension Division

of apprenticeship in the painting craft is past and that some other means of preparing competent journeymen mechanics were necessary. This course will be followed by other and more complete ones and marks the first step in the development of educational training under the guidance of a state institution.

The Automobile Institute is being put on in the different cities of the state of Iowa, primarily, to teach automobilists, and those who expect to become owners of cars, the principles of the operation of the automobile. There is probably no equipment which is so complicated as the modern automobile, involving as it does, so many principles of mechanics of power generation, and lately the electrical equipment and control. Of the 70,000 automobile owners in the state of Iowa, which is more than there are in the state of Michigan where fully one-half of the automobiles of the country are muufactured, these institutes will probably reach twenty or thirty thousand owners. The plan is to put an automobile expert into a community to conduct either a three day or five day institute, with special emphasis on the principles of operation of the car, and the methods by which the up-keep cost can be reduced. This is a non-technical and specialized service which will result in a direct dollars and cents return to the citizens of the state. The institute is accompanied by exhibit boards, charts and illustrations, enabling the lecturer to fully explain the principles involved. It is not in the nature of an automobile show but rather a technical service. Mr. R. E. Davis, an Ames graduate, has been placed in charge of this work. Mr. Davis was formerly Chief Engineer of the Midland Motor Company. The service has met with the heartiest response from the manufacturers, dealers, owners, repair men, and automobile clubs. In general, the expenses of the institute are borne by the Commercial Club and the attendance thrown open to the citizens of the county.

THE IOWA ENGINEER

Published Monthly During the College Year by the Students of the Division of Engineering, Iowa State College, Ames, Iowa

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EDITORIALS

The Mechanical Engineering Department and students are justly proud of the new Steam and Gas Laboratory which was recently completed and is being rapidly equipped with the most up-to-date apparatus of its type. This is the culmination of years of careful planning, and great credit is due Prof. Meeker and other members of the mechanical department for their ceaseless efforts to provide for the student an opportunity to familiarize himself with systematic methods of conducting tests on steam and gas apparatus.

Among the more notable equipment is a fine new Ingersoll Rand cross compound two stage air compressor, capable of compressing 534 cu. ft. of air per minute, and a 114 h. p. cross compound Corliss engine supplied with high pressure steam from

a modern Sterling type of water tube boiler. In the near future a Diesel oil engine will be installed. The large test floor and other facilities will enable trial tests to be made on various types of machines sent in by the manufacturer. This will prove advantageous to the student and manufacturer alike. The student will have access to modern, up-to-date machinery and appliances. The manufacturer can thereby have his product tested more thoroughly than his facilities would admit, and thus can knowingly perfect his designs on the basis of these tests.

More equipment will be available than the undergraduate will find time to work with; in addition some of this will be too complicated for his mastery, so that the addition of an attractive post graduate course in steam and gas engineering is anticipated.

At the present time many different kinds of steel and iron construction are being standardized by manufacturing concerns. A uniformity of design results which proves to be an economy for the manufacturer and an assurance of safety for the purchaser. The technical student, as well as the practicing engineer, should familiarize himself with these standards in order to intelligently design or specify the more modern structures. The American Bridge Company maintains a Bureau of Standards which, among others, has compiled a book entitled "Standards for Detailing," for steel bridge and building construction. This book will be very valuable to any engineer or student having anything to do with the design or construction of steel bridges or buildings.

Mr. J. E. Banks, B. C. E. '89, has been in charge of the Bureau of Standards of the American Bridge Company at Ambridge, since 1908. He describes "Standards for Detailing" in this issue, and specimen pages are shown.

We wish to call attention here to the article in this issue, "Specifications and Tests for Drain Tile," by Prof. R. W. Crum. As pointed out by Prof. Crum, the use and manufacture of drain tile in Iowa is enormous. Since so much money is involved in tile drainage in this state it is imperative that the proper testing and manufacture of cement and vitrified tile be given due consideration. A machine for finding the breaking

loads of tile has been designed by Dean Marston and has been in successful use at the Engineering Experiment Station for several years. The possible loads that different sized tile must bear in ditches has been determined experimentally here at Ames in 1912, and the results of the tests are contained in Bulletin No. 31, issued in February, 1913. The above are two important steps toward the ultimate specifications for Iowa drain tile.

The remaining steps are now being taken by The American Society for Testing Materials, through its committee of which Dean Marston is chairman. From the results of the tests upon drain tile made here recently, and knowing now the loads that tile must carry in ditches, this committee will soon report standard specifications for drain tile to the society.

The ultimate value of these specifications to the people of Iowa cannot be estimated. Manufacturers will be able to make tile with reasonable assurance that they will not fail under common conditions, and the land owners will be safe in using a standard product. In all probability these specifications will be used throughout the United States.

The recent engineering short course, which comprised lecture and laboratory work in Gas and Steam Engines, Power Plant Operation, Heating and Ventilation, Application of Electricity, Clay Working, Use of Cement, Road Making, Drainage and Interior Decorating, was a complete success far beyond the anticipation of those in charge of the work.

Among those in attendance were manufacturers, engineers, shop employes, farmers and other craftsmen. In almost every case these men were highly gratified with character of work offered, and ask that it be repeated next year. The courses will be broadened as occasion demands.

Iowa State College has taken the initiative in this venture, and the success and popular approval met with will doubtless be conducive to other schools in offering similar instruction in the future.

Dr. Elwood Mead, the world's foremost irrigation authority, is to become a member of the University of California faculty, according to information received by us recently. Dr. Mead

has been engaged as head of the irrigation and water divisions of the Victorian Government in Australia for the past eight or ten years. His work has been that of installing the great irrigation system there and he has made good with the Victorian Government. He left the position of Director of the Department of Irrigation Investigations at Washington, to take the position in Australia, and it is understood that the Victorian Government has made overtures to retain his services, but as Doctor Mead's interests lie mainly in this country, he decided to accept this honorable position with the University of California, and will become active in irrigation affairs immediately upon his return.—Irrigation Age.

Dr. Mead graduated in Civil Engineering from Iowa State College with the class of '83. It will be remembered that he addressed the C. E. Society two years ago, at which time he was spending his vacation in this country.

A large number attended the course in highway engineering. given by the highway commission in conjunction with the engineering division. There were eighty men enrolled for the two weeks' course, and during the last two days there were over one hundred and twenty-five present. The enrollment consisted mostly of county engineers from this state, although there were some engineers from adjoining states, and some contractors.

So far as is known this is the first time that an attempt has been made to give a technical course in highway engineering in two weeks.

Both from the standpoint of the highway commission and of those enrolled the course was a success. It also served to accentuate the friendly spirit that exists between the commission and the engineers of the state.

Three state highway engineers, A. R. Hirst of Wisconsin, A. N. Johnson of Illinois, and T. H. McDonald of this state, addressed the meetings. J. M. Brockway, Sen. A. L. Ames, and Speaker Cunningham, members of the legislature that passed the highway law, also spoke. A similar course will be held next winter.

Several farmers enrolling for work in the engineering courses was one of the unique features of the recent short course. These

men were interested in the development and use of power on the farm, and they took the course for the work in steam and gas engines and electricity. The course was intended primarily for shop employes and men in charge of manufacturing plants. It was not very successful in reaching this class of men, and the reason is attributed to the lack of proper advertising. However, the total enrollment reached sixty-five, which was much larger than was expected.

Tau Beta Pi, honorary engineering fraternity has been active among the faculty and alumni. At a recent meeting M. P. Cleghorn, B. S. in E. E. '02, M. E. '07, R. G. Norman, B. M. E. '03, M. E. '09, associate Profs. in Mechanical Engineering, T. R. Agg, B. S. E. E. '05, Prof. Highway Engineering, J. B. Davidson, B. S. M. E. '04, Univ. of Neb. Prof. of Agricultural Engineering, and H. F. Anthony, B. C. E. '05, engineer in charge of concrete construction, Keokuk Power dam.

Alumni Notes

E. C. Boutelle, M. E. '93, is with the Central Iron Works of Chicago. They are manufacturers of all kinds of steel and iron goods.

C. C. Lewis, M. E. '95, is engaged in the manufacturing of ice at Carlsbad, N. M.

Porter Eveland, E. E. '03, who is with the Colorado Power Co., has changed his location from Salida, Colo., to Denver, where he has headquarters in the Symer Building.

Geo. V. Pew, M. E. '04, is Vice-president and Secretary of the Geo. E. Pew Co., Inc., of Le Mars, Ia. They handle farm machinery, buggies, windmills, threshers, engines, and automobiles.

J. E. Buell, C. E. '05, who is chief engineer of the United Steel Co., at Carton, Ohio, was a campus visitor last month.

C. C. Clauson, E. E. '07, has a responsible position with the Whatcom County Railway and Light Co., at Bellingham, Wash.

A. E. Berggren, M. E. '08, is instructor in Thermo-Dynamics in the Engineering College, University of Wisconsin. He spends the greater part of his time in engineering research work. He expects to get his master's degree this year.

H. F. Anthony, "Mike," B. C. E. '05, addressed the Iowa Cement Users while in session at the college January 8, 9. "Mike" was engineer in charge of concrete work of Illinois Division of Keokuk Dam.

H. A. Wilkinson, E. E. '12, has left the Alamo Electric Supply Co., at Omaha, to take up efficiency engineering work in New York City.

P. H. Ottosen, C. E. '08, visited on the campus just before the holiday vacation. Mr. Ottosen is now in the army engineering corps in the coast artillery and his visit was made while on his way to the Philippines where he has been recently ordered.

Paul S. Drew, C. E. '12, who is with the Oregon Short Line at Pocatello, Idaho, visited on the campus last month.

The classes of '74, '79, '84, '89, '94, '99, '04 and '09 are starting their campaign and making their plans for a special reunion next June.

The class of '84 has been stirred to enthusiasm through the initiative of Prof. Geo. R. Chatburn, C. E. '84. He has instituted a series of "Broadsides" containing letters of autobiographical nature from all the class members who will contribute and these are being sent to all members. In one of these Prof. Chatburn has given a very interesting account of himself. In 1894 he went to the University of Nebraska as Instructor in Mathematics and Civil Engineering. Since then he has become Head Professor of Applied Mechanics and Machine Design. In addition to this he is head of the course in Highway Engineering. Outside of the University he has been very active in the good roads movement and also for municipal improvement, having covered the state with letters and talks on these subjects. At present Prof. Chatburn is engaged in writing a text book on the "Materials of Engineering Construction."

Of the five positions as valuation engineer, opened by a recent United States law, one was filled by an I. S. C. graduate. Mr. F. L. Pitman, B. C. E. '84, was appointed as District Engineer for the Pacific District.

By this law the United States is divided into five districts, each in charge of a division engineer. The work of these men will be to value all of the property of interstate common carriers, such as railways, telephone and telegraph companies, etc.

Mr. Pitman is admirably fitted for this work, as he has been engaged on no less than ten different railways as transit man, location engineer and chief engineer. At the time of his appointment he was chief engineer of the North Coast Railway, with headquarters at Spokane, Wash.

Twenty-five Ames students and alumni, residents of Omaha, held a banquet at the University Club, Dr. A. C. Stoke acting as chairman. After the dinner was completed, an alumni club was organized. There were several engineers present.

Mr. W. E. Kunerth, of the Physics department, has just completed a series of tests on various grades of oils and gases. The data, which cover the lighting and fuel values of the oils, flash tests, etc., will be issued in a bulletin.

Prof. W. H. Meeker has checked the designs for the concrete chimney at the power plant, and finds that the steel and concrete are not over stressed. It is probable that work will be continued as soon as the weather will permit.

OBITUARY.

News has been received of the death of O. F. Lenning at the hospital in Ellsworth, Iowa, being inflicted with stomach trouble. Lenning was formerly a member of the present senior Mechanical class. He has been employed with John Deere & Co. the past year at Moline, Ill.

Harry S. Gray, C. E. '06, died recently in California. Mr. Gray was formerly Assistant Professor in Civil Engineering at Iowa State. He left that position on account of bad health.

Every Engineering student should read the Iowa Engineer every month. When our agent calls on you be loyal and give him your subscription.

THE IOWA ENGINEER

CONTENTS

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The Engineer

HE is the lord of modern things and times. His hand it is that strews the dragon-teeth of courage in the furrows of our dreams; he covers them with warm and passionate labor in the silence of the violet hours when others sleep; in the sweat of his brow he waters them, and in the devotion of his soul he brings them forth into the glamor of Today—giant armies of giants, triple-armed to the service of mankind, against which none may prevail save he who brought them into being.

Where Nature flings a mountain-chain to bar the human host from further progress, his is the eye that piercest to the weakest link, and his the hand to guide the furious force that rends the bar asunder.

He strides across the blazing desert-sands where Death has ranged since first the world began; he turns aside the rivers, long-league wide, and leads them out across the arid waste to conquer Death and give his wide domains to Man.

The elements are tools unto his craft: with Fire and Water mingled into one he works his utmost will upon the earth. On pinions wrought of canvas and of steel, he wings across the reaches of the air, far swifter than the vengful winds of Storm can follow him. A thousand times he risks his life, a thousand times he dies; and yet lives on, and ever shall live, till the universe of things Inanimate shall yield to him its last and utmost store of Good!

C. HENRY.

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The Decline of Navigation on the Inland Waterways of the United States

R. B. DALE*

The water borne traffic on the inland rivers and canals of the United States formed a considerable amount of the total handled prior to about the year 1890. Since that time not only has the proportion of traffic handled by water to that handled by rail steadily diminished, but the total amount handled is considerably less and is constantly decreasing. In searching for a reason for this decrease, it is not enough to say that the rivers and canals have outlived their usefulness as carriers of traffic. There is no doubt as to their ultimate value for this purpose; but, in order that they may be used to the greatest advantage, they must, first, fulfill a demand and, second, both the waterways themselves and the means of navigation must be improved so as to provide the greatest economy and convenience that is possible under the circumstances.

The location of an inland waterway with respect to the demands of trade largely determines its value as a carrier of traffic. The greatest example of inland waterways in the world is the system of the Great Lakes with its highly organized ship-

*Professor of Correspondence Courses in Engineering Extension

Highway Lift Bridge and Lock, Illinois and Mississipi Canal.

the industrial and agricultural growth of the Mississippi valley, is yet of sufficient magnitude to be a small factor in the transportation interests of this region. The Missouri River has decreased in importance as a carrier of water borne traffic until it may no longer be mentioned as a factor of influence in connection with the interest of the Missouri valley. There is an important and ever increasing north and south movement of freight and, taking into account the congestion of railroad freight traffic, especially during the harvesting season, it seems that there should be an increase in the amount of water borne traffic on the Mississippi River. Such, however, is not the case but the opposite is true. In spite of continued and effective improvement of the stream, the total amount of shipping is rapidly falling off in volume.

There are a number of contributary causes. It is sufficient to mention some of these briefly. If we examine the history of water transportation in Europe, it will appear that the waterways were at an advanced stage of development before the railroads had gained a foothold. The natural waterways offered a comparatively rapid and effective means of transportation before the development of the locomotive and before the organization of the great railroad corporations which exist today. The result was that, since the people were dependent upon the natural water courses as a means of transportation, they were given

a great amount of attention early in history. In this country the development of the western plains is contemporary with the growth of the transcontinental railroad. Although the Mississippi was used as a carrier of traffic to a considerable extent prior to 1873, the date of the first comprehensive improvement of the river, yet the Union Pacific railroad was completed and the last spike driven May 10, 1869. From this time the building of railroads went rapidly on, until we now have the most highly developed system of railroads, considering the extent of territory served, in the world.

Not only has the early history of the use and development of the natural waterways in Europe and the United States exhibited widely different conditions, but the problems of the present are widely varying. The thickly populated districts of Europe present vastly different economic conditions than do the regions of the United States. England, for example, is economically hampered by enormous armies of unemployed workmen. This results in a low wage scale for common labor; hence the item of time is not so valuable a consideration there as in this country. The older countries of Europe have consumed a much larger proportion of their heritage of natural resources than has the United States. They are now not only obliged to conserve their resources by a more painstaking elimination of waste, but they must use them more intensely. Accustomed by long years of practice, the people are willing to economize their productive resources at the expense of time and convenience. They make use of resources of which we have not yet been forced to learn the value. The United States possesses today a system of inland waterways and navigable rivers not inferior to any of the countries of Europe. It is an undoubted fact that water transportation under favorable circumstances and from a standpoint of operating expense alone, is cheaper than transportation by rail. The conclusion is that we have not yet discovered the need of water transportation. Since the development of the great railway systems we are glad to use the advantages of expeditious despatch and convenience which they afford, even though it be at the sacrifice of a small saving in cost.

It is easy to see that the railroad is a serious competitor to river transportation. The railroads are not confined to the dis-

An excellent view of the Stone Arch Bridge and Milling District of Minneapolis

trict through which the river flows. They have an efficient means of routing freight over various lines in order to reach rapidly and economically the most remote station. The interior towns are as accessible from a railroad point of view as are the river towns. It is difficult at the present time to make a combined rail and water shipment. The transshipment from boat to car is not easy to accomplish. Neither the railroad lines nor

Sinking a Mattress. Improvement of the Upper Mississippi River.

the regular boat lines are prepared to undertake arrnagements at intermediate points and the commission must be placed with local parties, which arrangement is both unsatisfactory and expensive.

Then again, the railroads have adequate terminal facilities, which the river does not afford. The variation of thirty feet in the water level at different seasons of the year makes terminal construction difficult and expensive. The contrast between the terminal arrangements at a sea or lake port and those of a river port is striking. At the former the loading and unloading of the vessels is accomplished by means of the most modern machinery designed and built especially for that purpose, and at the latter the loading and unloading is done by hand almost without exception, or at best with the assistance of mule teams. This antiquated method of handling freight at the terminals adds enormously to the total cost of transportation by water.

Wherever water transportation has reached considerable proportions, the railroads have entered the field, operated steam boats, purchased desirable water frontage and erected docks and elaborate water terminals. Thus the railroads have become their own best competitors in water transportation. This is entirely

proper. However, it should not be possible for the railroads or any other corporation or private parties to so control the water fronts that others are prevented from using them unless they are obliged to pay an unreasonable or excessive charge. The custom of the municipalities along the river to provide wharfs which may be used by any vessel in consideration of a small wharfage charge is to be commended. It should be possible to do away with the wharfage charge altogether, requiring only that the vessels be subject to the orders of the city wharf master while lying at the wharf.

Another serious drawback to river transportation consists in the perils of navigation. During the past few years a number of vessels engaged in navigating the upper Mississippi have been wrecked. Owing to the extremely low water navigation has been very difficult and the service has not been at all reliable. This fact, together with the shortness of the ordinary season, has made the last few years especially unprofitable for the operators. It is, indeed, doubtful if the regular freight and passenger traffic would justify continued operation were it not for the excursion business. This should be, and no doubt is, very profitable.

The national government annually spends several million dollars in the improvement of the Mississippi River and its tributaries. The amount so appropriated to date is about one hundred million dollars for the Mississippi River itself and considerably over two hundred million dollars for the Mississippi and its tributaries. It has been said that even if this expense is not justifiable from the standpoint of actual service rendered to navigation, the improvements actually do accomplish a lowering of the freight rate and obtain for the community served by both rail and water a so-called "water rate" which is considerably lower than that obtained by less fortunate communities. A few years ago it was possible to get a lower freight rate by rebilling commodities intended for interior points at a river point than was possible by consigning the shipment straight through to its destination. The Interstate Commerce Commission by the authority given to it by Congress has changed all this by a very just ruling that no community shall be differentiated against in the matter of freight rates. The basis of tariff for the transpor-

tation of freight both by rail and by water must be in the future, if it is not truly so at present, a scientific knowledge of the costs of operation. The profit of the carriers must be sufficient to attract capital and place the corporations on a substantial financial basis. The time has long passed when freight charges might be determined by the maximum amount which the railroads or other carriers may force the community to pay.

The improvements of our navigable rivers are in charge of the Engineer Corps of the United States Army. Every improvement must be authorized by Congress and money appropriated for the purpose by the same body. This authority is based upon reports made, after careful investigation, by members of the Corps. These reports have to do, as a rule, with the feasibility of the engineering construction only. The question as to whether the outlay is desirable from the standpoint of its service to the interests of water transportation is usually decided in the Rivers and Harbors Committee. The Board of Engineers may express an opinion but the real question is decided by Congress. The results of such a system have, in some respects, been evil. Improvements involving the expenditure of a large amount of money have been made, as one might suppose, for no other reason that that large sums of the government's money would be spent in the community interested. Another result of this policy has been that some of the work done has not brought about the expected results, and the works have been abandoned or might as well be abandoned. It must be remembered that those who know the rivers best have still a great deal to learn about them and that experiments on such a large scale are necessary even if they are expensive. For this reason it has sometimes been necessary to abandon certain works because their effect could not be accurately foretold.

In the face of these facts we are confronted with the question: Shall the United States continue to improve rivers for the purposes of navigation and to build canals and controlling works of navigation which are not likely to be used in the present or the immediate future to an extent which will at all justify the continued expense? We are agreed that it is possible that the rivers will be used extensively and intensively for navigation purposes in that future time when the density of population in

The big government lock in the Keokuk dam. This lock ranks with those at Panama.

the Mississippi valley shall have increased to several hundred inhabitants per square mile. There is no doubt but by that time the character of the country will so have changed that water transportation will not only be profitable but that the commercial interests of the country cannot well do without it. We are also agreed that it is the duty of the United States to conserve and preserve the rivers to this purpose. There are those

who would answer the question by saying that transportation interests should be invited and encouraged to use the rivers by improving them and making them useable by larger and better equipped vessels. There are no facts which would lead us to believe that they would be used extensively at the present time even under these conditions. It is impossible to create a traffic where the need for one evidently does not exist at present.

What shall we, then, do with our waterways? Obviously, we must maintain them for the small amount of traffic which does exist and in order that the benefits derived up to the present time may not be lost to the future. Let us do it, however, with the least possible expenditure of money which will maintain the existing channels. Incidentally we shall learn much that is valuable in connection with the economic maintenance of such channels. It appears further that it is also the duty of the United States to so control and manage terminal rights along our navigable rivers that they may not become monopolized either by the railroads or other parties.

Towboat Sprague, with the record breaking tow in which she took 56,000 tons of cargo coal down the Mississippi river to New Orleans

The Coal Industry in Iowa

E. A. SAYRE

The production of coal in Iowa in 1912 was 7,289,529 tons valued at $13,152,088. There were employed in and about the mines 16,370 employees.

Situated on the western edge of the Interior coal province, the Iowa mines in their own territory and to the westward possess a natural advantage in freight rates over their Eastern competitors. Offsetting this advantage, however, is a slightly lower grade in the quality of the coal and a higher cost of production. The latter is due to a higher scale in mining and natural difficulties encountered in the coal beds. The basing point for the interior coal field is Western Pennsylvania and Ohio where the initial scale fixed with the United Mine Workers is $1.00 per ton of lump. For Iowa the scale is $1.10 per ton.

The natural difficulties of mining in Iowa are due to the discontinuous nature of the coal beds. In Illinois and other states to the East, coal beds often extend over miles of territory with practically no variation in the level of the beds. In Iowa on the contrary, the coal horizons are workable only in pockets, one-half mile to two miles wide and perhaps twice as long. This holds true for practically all of the state except the Centerville District where the beds, though more continuous, are but thirty inches in thickness. In the Iowa fields, also, sudden changes in the elevation of the beds are common. Grades of eight, ten and twelve per cent are met with on the sides of the "swamps" or thick places in the beds.

The pockety nature of the beds makes the mines short lived. Of the sixteen mines in Polk county, that have been worked out and abandoned during the past seven years, the average life of each mine has been 9¼ years.

The limited extent of the coal beds has also had a tendency to keep the business in the hands of small operators. Fifty-eight per cent of the 110 operating companies of the state have a tonnage of less than 50,000 tons per year. Naturally the limited extent of the fields has discouraged the building and equipping

Eagle No. 3 Mine—A Typical Iowa Coal Mine

of elaborate plants on the surface. This has been especially true of the commercial mines.

In the southeastern part of the Iowa coal fields around Centerville and in the northern part around Boone, the work is longwall. Their tonnage is 20 per cent of the total for the state. Through the remainder of the coal fields, the mining is room and pillar, the coal being shot from the solid.

Formerly the shooting mines made but two sizes of coal, nut mixed and standard lump, the division being 1⅜ inch screen. During the past five years competition with Illinois coal in particular has caused the rescreening of the standard lump with shaker screens, and the sizing of it into range coal and chunks over six inches in size.

As the competition in the past forced a better preparation of the coal so the severer competition of the present will force a more scientific mining of the coal. At present Iowa is at the commencement of machine mining. During the year 1911 .6 per cent of the coal was mined by machines; during 1912 1.3 per cent. The slow introduction of machines is not due to any unwillingness on the part of the operators but to the short sighted policy of the miners and their officials in fighting their introduction. Up to the present, in the shooting mines of the state, the miners have permitted machines to be used only in deficient places where the coal was not thick enough to be worked profitably by hand. In the longwall mines around Centerville, after several years of varying fortune, the machines have finally obtained a permanent foothold. The general tendency all over the state is toward the introduction of machines. The competition of Eastern coals is forcing it on the operator, and the ill-advised attitude of the miners must change and a fair scale be granted. When this occurs there will be a wholesale introduction of machines in the shooting mines.

Another notable tendency is the electrification of the mines. Electric hoists, fans, and pumps are replacing steam operated plants. The majority of the new mines are being electrically equipped. In most cases the current is purchased from interurbans or lighting plants instead of being generated by the mining companies themselves.

Although the tonnage for the past few years has been prac-

Driving a twelve foot entry.

tically stationary, the present outlook in the Iowa coal industry is optimistic. Several of the largest coal fields in the state on the new Chariton line of the Rock Island are being opened up on a large scale. This, together with the advent of machines in the state, will undoubtedly result in a greatly increased tonnage in the near future. Better methods of mining coal and better preparation of the coal will enable the Iowa operator to successfully compete with his Eastern competitors.

Henry Ford is preparing to spend $1,000,000 for a unique gas engine electric power plant for his Detroit factory. The power will finally be converted into electricity and in this form will be distributed through the great factory. The power will be produced by four big 6,000 h. p. engines, which may best be described as hybrids of gas and steam.

Each engine will have four cylinders in tandem on each side, one pair of cylinders being operated by produce gas and the other by steam. The steam will be generated from hot water heated in the water jacket of the gas engine, further heated by exhaust gases and by waste heat from the producer gas plant.

Principles Affecting the Design of Projects for Flood Relief

[*Editor's note: The controlling of excessive floods presents a problem in many states of which Iowa is not an exception. Since the floods of March, 1913, in states bordering the Ohio and Mississippi rivers, the attention of many engineers has been given to investigating and designing methods of controlling floods. As a result, certain general principles are being laid down that must be observed in nearly all methods of flood protection. The following general principles have been taken from the Report on Flood Protection for the City of Columbus, Ohio, by Messrs. Alvord and Burdick, Engineers, Chicago, Illinois. While these principles have been developed from an investigation of conditions in but one locality, yet they seem to apply to nearly all situations when the controlling of stream flow is desired.*]

In any effort to determine which of several projects will be the best and most economical for flood protection at Columbus, it will be desirable to settle upon principles and safeguards which should govern each project, and their comparative efficiency.

A certain factor of safety should be adopted common to all the projects, and methods of treatment complying with good engineering practice should be introduced into all the protection work. It is proposed to discuss these principles and lay down certain rules which shall serve as guides in forming projects for flood relief.

MAXIMUM FLOOD TO BE PROVIDED FOR.

For the purpose of comparison, the projects which are to be considered are based on two classes of floods with maximum flows of 200,000 cubic feet per second and 150,000 cubic feet per second, respectively. These figures are in excess of the flood of March 25th, 1913, by 43% and 7½%.

CHANNEL CAPACITY.

Aside from an allowance for floods in excess of that of March, 1913, good engineering practice would require that all channels,

levees, walls, bridge openings and waterways generally, should have a capacity even beyond the assumed flood flow. This capacity may be denoted as the "factor of safety."

In this report it is proposed to adopt not less than 4 feet, and in most cases 6 feet, as being the minimum levee heights and bridge clearances above high water. This is consistent with good engineering practice, and desirable as an additional factor of safety. Except at street and railway crossings the height of levees will be made 10 to 12 feet higher than the flood flow line adopted. This will add about one-half more capacity to the actual flood quantities as stated, under emergency conditions.

BRIDGE CLEARANCE.

In the case of clearance under bridges for all main channels it is desirable that not less that 4 and preferably 6 feet of clearance should be maintained. Great floods always produce a large amount of floating debris. Buildings of considerable size, lumber, trash, barns, out-houses, fences and other floating material pass down the stream, collect at the bridges, clog the existing openings, reduce their capacity, and increase the flood level above to heights for which no previous calculations have been made, overtopping levees which otherwise would be entirely safe. It is of great importance, therefore, that bridge openings throughout Columbus should be ample.

ADDITIONAL LEVEE HEIGHT.

It is desirable on certain important levees to have even more than usual height. There are obstacles to making a levee freeboard everywhere greater than 6 ft. as that would require all of the streets and the steam railroads crossing the levees to be raised for long distances away from the river.

But where ample excavation is available, and where street crossings do not often occur, levees can be made higher than 6 ft. above the high water mark to advantage. Such greater height may be lowered at the crossings, and yet give opportunity for a class of flood protection even above a freeboard height of 6 ft. above the highest water. This is because in great floods or in ice jams time will be had to rally to the protection of exposed or low points of the levees as at railway and street crossings. Such low points if not too great in number may be raised

quickly by sand bag closures. While such contingencies are not apt to occur, the sense of security which will be created by the possibility of excluding water at accidentally high levels should not be neglected.

Where possible, therefore, levee heights will be made 10 or 12 feet above the highest water mark proposed. This holds at levees of special importance protecting populated areas and also where there is a surplus of excavation obtainable.

WIDTH OF LEVEES.

A great width of levee does not always mean increased strength. Experience along the Mississippi River would appear to show that from 10 to 15 ft. top of levee is quite sufficient to hold back the water of the river with safety, especially where provision is made to protect against erosion or wave action on the water side.

In Columbus conditions exist which make it advisable to adopt a more ample width.

Most of the projects will develop a large amount of excavation in excess of requirements for actual levee needs. There is no place for it so convenient and useful as the adjacent levee. To widen the levee therefore under such circumstances as this is not to make them more expensive, but really lessens the cost of the work as a whole.

Another reason for broad levees is that their top may form drives of a feature park way. The present plans will not be made more costly in providing for this future possibility.

PAVING OF LEVEES.

At certain points levees become subject to excessive erosion by the great velocities created by floods. With channels of ample capacity, such velocities are not usually created. But there will often be some exposed points where the velocities may reach the scouring speed. Where such danger may occur levees should be protected by rip-rap or other paving on their inner slopes.

MATERIAL OF LEVEES.

The material of the levees should consist of a mixture of gravel, sand, clay and earth so proportioned to form impervious material which can be laid down in layers and thoroughly compacted as the embankment is raised. The original top soil should

be removed from the ground where they are to be built to obtain imperviousness. Cut-off trenches should be provided in the foundation where necessary.

IMPROVING TOPS OF LEVEES.

It will add to the safety as well as to the appearance of the levees if willows and underbrush are planted on their slopes and a double row of trees could be planted upon their tops to advantage. In the future, these may become the shade trees of a driveway.

VELOCITIES.

In considering velocities which will be created, we come to one of the most important difficulties.

It has been thought that the ample fall across the city or around the river channel is an advantageous feature in the treatment of the flood problem. Quite the contrary is the case. The excessive fall which is found in all of the auxiliary channels is a distinct embarrassment in designing structures and waterways for control of the floods. Such great falls produce excessive velocities which in a few hours would tear away the strongest embankment, if not properly protected. Visible evidences of the destructive force of water at high velocities is one of the deep impressions which the people of the West Side have received during the flood of March, 1913. Those charged with the responsibility of designing channels should so shape their design that such destructive velocities will not happen, or if they must occur, a protecting structure or suitable revetment must be introduced. Accordingly it is of first importance that the slope of the flood be carefully regulated.

For a flood of the magnitude we are here considering, a drop of from 1½ to 1¾ feet per mile in a channel of efficient depth is all that can be safely considered. A greater drop than this will produce velocities which are disastrous. The flood of March, 1913, had a drop from the Grandview Avenue bridge to the Sewage Disposal Plant of nearly 4 ft. per mile though it was not confined to one efficient channel, and its destructive effects, by reason of the velocities thus created, will be long remembered.

A channel carrying a flood with a mean or average velocity of about 6 ft. per second sustains the greatest average speed which

may be safely allowed with ordinary banks of earth without special paving for protecting surfaces. A flood velocity of 6 ft. per second will mean that the velocity in the center of the current will range from 7 to 9 feet per second, while the velocity along the edges of the shore or along the bottom will be between $2\frac{1}{2}$ and 3 feet per second, and velocities above this begin to scour the finer materials which they encounter in their course. It would seem, therefore, as a first principle to be laid down, that in designing flood water channels of earth the fall should be so limited that no velocities will be produced much exceeding an average velocity of 6 feet per second. A greater velocity may be allowed for bridge openings and for short distances. This will require that bridge piers and abutments are deep and adequately imbedded on good foundations; also they should be sufficiently protected by rip-rap work on their up and downstream sides. Under such conditions, a maximum velocity of 10 ft. per second may be permitted for a short period.

CONTROLLING WEIRS.

To control flood velocities it will be further desirable to introduce low dams or controlling weirs, which will allow the water some drop at places which may be amply protected. It will not be safe to let it down more than a foot or two at these dams, but in most of the projects there will be found low dams having this function. They do not obstruct the flood flow at high floods to a dangerous extent. At times of lower water they will have the added advantage of pooling the water above them in the river.

THE FLOOD WATER GRADE.

The flood water grade, by the aid of these weirs or dams may be so designed as to have only that fall which is safe and desirable. The adoption of a proper flood water grade controls the proportional amount of deepening and widening which must be done to obtain the necessary cross-section of the stream.

It should be remarked that effective cross-section can be often obtained as well by deepening as by widening, but it is not always possible to maintain depths once created. A judicious compromise between these two methods of obtaining cross-section is desirable. Some deepening—not enough to give rise to

perplexing problems of maintenance, together with judicious widening, no more than can be helped in expensive and built-up territory, is obviously the true compromise for an economical design.

SIDE FLOOD CHANNELS.

Above the populated district, the carrying capacity of the bottom lands may be improved by the construction of side channels with bottoms somewhat above low water of the river and so constructed that they make cut-offs across the bends of the low water channel. When the rising flood water enters these side channels they will carry the flood water with lower flood heights than would be the case otherwise and the excavation from them is convenient for levee building.

LOW WATER CHANNEL.

The low water channel of the river will be maintained as it now is for all ordinary purposes. At certain points where large amounts of flood water must be passed through the city in a limited space, the low water channel may be widened into pools by which the cross section may be increased. Such pools may be regulated by the low dams heretofore described.

MAINTENANCE OF DEEPENED CHANNELS.

It has been noted that cross section capacity for flood flows is as effectually obtained up to certain limits by deepening a channel as by widening. This may be accomplished by dredging. This hydraulic principle is true notwithstanding the fact that deepened pools become wide and shallow channels later. The natural condition of all rivers are deep pools succeeded by bars and shallows. Flowing water is so mobile that it is capable of quickly changing its mass into different shapes, in accordance with the form of its bed and bank. It must, however, have the proper area of cross section in which to flow for any considerable distance. With a given surface slope in two channels, one of which is wide and shallow and the other narrow and deep, the velocity will be about the same if the areas and wetted surfaces are the same. This important principle enables us to effect a good deal of economy in providing deeper and more effective channels through valuable and populated territory.

There are objections to too much deepening of channels which must not be overlooked. Silt or sediment may deposit in such deepened places and gradually fill them. At low water these deepened places become pools. Where the velocity of flow of the lower and silt carrying floods is checked, suspended matter is deposited therein. Such sections as are deepened must therefore, either have little or no flow through them ordinarily or they must be on a river carrying little sediment or must be protected from sedimentation and maintained by dredging at intervals.

WALLS.

At certain exposed places it is desirable to obtain all of the cross section possible and at the same time create velocities greater than a safe limit. For this reason, it is desirable in some instances to build walls along the sides of the channel. Walls are also desirable where the land behind them is valuable. Where they are built no land will be needed to form slopes for the river.

STREET BRIDGES.

In the construction of bridges, some general principles should be introduced.

Concrete bridges have been somewhat criticised in recent floods at Dayton and other places as being serious obstructions to the flood waters. This is quite true where such concrete bridges have not been designed with ample waterway for the record breaking flood, and it is also true where they have not been designed with the necessary clearance above the high water of such floods, so that the debris and floating trash and ice jams may pass freely under them. But where concrete bridges are well designed, there is no reason why they should not have the confidence and approval of the community as against steel bridges so commonly used in the past.

Where bridges have to be of the full width of the street there is but little difference in the first cost between concrete arch bridges and steel bridges, and if the greater life of the concrete bridge and its lower maintenance cost be taken into consideration, the concrete bridge easily is the cheaper in the end.

It is believed to be wise as a general principle in making estimates for all of the various projects, that such enduring bridges

should be selected wherever the traffic conditions are as important as they are on the streets before mentioned, and others like them.

OUTLYING ROAD BRIDGES.

In the bridges in the outlying districts of the city in the upper Olentangy and the Scioto below Mound St., quite a different condition exists. The travel upon these bridges is not so great but that a day or two of inconvenience may be endured while a large flood is passing. In many cases such bridges need not be extended or increased in capacity at this time, but the approach roads which lead to the bridges over the flood water plain may be kept low and be so well protected that while all small or minor floods may pass through the ordinary bridge opening, a large or heavy flood will rise over the road and freely pass on its way with its accumulative debris without feeling the contracting effect of bridge openings.

The general principle, therefore, may be followed wherever it is desirable to economize the cost of bridge work by the introduction of these protected and flooded approach roads.

RAILROAD BRIDGES.

The principle to be observed in dealing with the railroad bridges is to avoid changes in elevation wherever possible. Change of grade often involves long stretches of approach track, complicated, perhaps, with switches and crossings and side tracks on either side, and is expensive. In the projects here considered, it will be wise to keep the flood water line as low as is consistent with reasonable cost in view of the difficulties that would be encountered by a general raise of grade. In many cases, however, even then it is necessary to require railroad bridges to have larger opening, and adequate clearance. It must be certain that all railroad bridges have beneath their girders and above the high water, room for debris and floating materials and ice brought down by large floods. This will make it imperative in some cases to raise the railroad bridges to a higher level and in extreme cases to raise some of the approach track to such railroad bridges as well.

As a proper policy the grade of the flood waters cannot be limited by the lowest bridge openings now existent. The grade

should be conformable to the majority of the bridges, and the lower ones must be improved.

A CLEAN RIVER.

The present condition of the Scioto River in dry and warm weather, is not to be tolerated in the future. There is no question but that this opportunity should be seized to improve the sanitary conditions of the river. Within the city, no sewage or filth of any kind should pollute the pools which must be formed in the river by the dams and weirs which are necessary adjuncts to flood protection. Storm water sewers, therefore, should be provided where possible, to convey the discharge from the sewers to points below the city.

RESUME.

Reviewing, briefly, the general principles that should control the design of the projects for flood control we may sum them up as follows:

1st. The high water mark for flood grade shall be kept as low as possible, consistent with economy, so as to prevent complications arising from any general grade raising throughout the west side of the city. Above the populated district it shall be lowered by increasing the capacity along the danger points adjacent, and below the populated district it may be left at its present or even somewhat higher levels.

2nd. In providing for large floods in channels of efficient depth, the flood grade or surface fall between earthen embankments or levees, should not exceed 1½ ft. per mile, or to put it in another way, the mean average velocities in such channels should not be greater than about 6 to 8 feet per second.

3rd. Where greater velocities than this may occur they should be controlled by dams, so as to drop the flood level within a limited area where its force can be dissipated without danger, in protected banks and bottoms.

4th. In exposed locations around bends or where high velocities must occur, rip-rap pavement must be provided on the levees; in some cases walls may be desirable.

5th. The least allowable heights for the levees should be 6 feet above the high flood water line.

6th. The ordinary height of levees above the high water line,

where excavation can be had for their upbuilding, and where there are infrequent bridge crossings, may desirably be 10 or 12 feet above the highest flood water line.

7th. Bridge openings should have a sufficient width and depth so that maximum velocities necessary to pass the flood flow will not exceed 10 feet per second.

8th. All bridges shall have their lower girders or archways at least 6 feet above the highest flood water line, as a precaution against obstruction by floating debris or ice at times of extreme high water.

9th. Where excavation is available and opportunity occurs for the purchase of reasonably priced lands, the levees should have a width of 80 to 100 feet upon their tops.

Power Plant Progress

G. G. HOSKINS '14

The following is an abstract of an informal talk recently delivered before the Iowa State College branch of the A. I. E. E. by Prof. H. H. Norris, Associate Editor of the Electrical World.

The large and rapid increase in the size of electric plants during recent years has brought about the necessity for larger generating units, better driving engines, and the utilization of more B. T. U. per pound of coal. Of the three elements of the electric plant the generator has reached the highest stage of development, and rapid progress has been made in the design of driving turbines, but the boiler room is a field practically untouched until recently by the efficiency expert.

In the generation of electric power the fields of the electrical and mechanical engineer so overlap that the central station man must have the qualities of both. The electrical apparatus is only a small part of the machinery that is to furnish the consumer with power at the lowest possible cost. Getting the power to the generator is over half the problem. It may be said that the electrical end of the modern power plant is run on a more scientific basis than the mechanical end. From the very first use of electricity for commercial purposes the switchboard was literally covered with meters to measure accurately every action

that took place. Only recently have pyrometers, steam-flow meters, flue-gas analyzers, and such instruments made their appearance in the boiler room.

Little room is left for great development in the alternator. Better insulation is constantly being made and better steels for the magnetic paths are being developed. The principal issue here is ventilation to reduce the heating of the machine, at the same time insuring strength and keeping the cost down. The use of the high-speed turbine has brought the need for more compactness in construction and better steels to stand the stress due to high peripheral speed. The highest-speed large units in practical use today are those of 5,000 K. V. A. capacity running at 3,600 r. p. m. The highest speed for the turbine is set by the fact that 60 cycles is the standard frequency in the United States and 60 cycles are secured when a two-pole machine runs at 3,600 r. p. m. Lower speed turbines as large as 25,000 K. V. A. are in operation and 35,000 K. V. A. machines are under construction. Direct current machines are not used at the higher speeds owing to the difficulty encountered in securing good commutation. It is readily seen, then, that the only alternative for increase in bulk and cost of large alternators and turbine units is increase in peripheral speed. Many competent engineers are at work on the development of better grades of steel and some very gratifying results are being obtained. Larger very high speed units will undoubtedly come into general use as the better steels are made possible.

The perfection of the steam turbine has given a new impetus to the generation of electric power by steam. It combines the two essentials, low cost of manufacture and high mechanical efficiency. The speed of the turbine is not limited by the alternator from a mechanical standpoint and since the highest speed machine is usually the cheapest for a given power the standard speed will probably ultimately be 3,600 r. p. m. Double-flow turbines are used to some extent in the large installations but at present turbines vary greatly in design. Strength to withstand high speeds and utilization of all the energy in the steam furnishes the chance for the efficiency expert in the turbine design.

From the standpoint of space required the engine room is only

a small corner in the plant. The boiler room is the big part and here lies in proportion the big chance for economy. By modern methods the boiler efficiency has been raised from 40-50% to 80% and higher. It was formerly the general belief that if a man could heave enough coal to keep up the steam pressure he was a good fireman and no criticism as to his lack of brains was made. This idea is fast becoming a relic of the past golden age of ignorance. Nowadays the fireman must understand that the best results are obtained by careful attention to detail. He must know the consistency of his flue gas. He must keep the height of the water in his boiler constant and not let it get low and then flood the boiler, thus causing a wide variation in temperature. The modern fireman knows how much coal he is burning per pound of water evaporated and strives to get the best results out of the least fuel. He has time for these things, the automatic stoker and other labor savers giving him the opportunity to use scientific methods. The greatest improvement in the boiler itself has been the increase in draft and the corresponding decrease in grate and heating surface per boiler horse power.

Efficiency and low cost of production is the slogan of the modern manufacturer and in no place is the value of this slogan more keenly felt than in the manufacture of electric power. Scientific application of modern knowledge is bringing about the solution of the problem of producing highest mechanical efficiency and cheapest power.

THE IOWA ENGINEER

Published Monthly During the College Year by the Students of the Division of Engineering, Iowa State College, Ames, Iowa

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EDITORIALS

A very favorable opportunity seems to be frequently overlooked in the selection and disposition of the various apparatus and machinery to meet the everyday needs of the college. A good percentage of our indispensable equipment could be designed and built with little if any increased expenditure than is customary, so as to be utilized for laboratory purposes, as well as fulfilling a daily service. This scheme would be of particular advantage to the student as it would provide him with "life size" laboratory equipment. At the same time duplication of apparatus would be avoided, which would effect a marked saving.

Then again, no little amount of equipment is at hand, but located in some dark corner or out of the way place, so as to

be inaccessible or impossible for student use. By setting this in a clean, light place, or possibly isolating it from undesirable surroundings, its usefulness would be unimpaired. At the same time it would be at the student's disposal for experiment and investigation. For instance, at Ames a model water filtration plant and sewage plant could be installed to good advantage, which would serve as an example of good, modern design of that type of structure, at the same time meet an urgent need, thus fulfilling a two-fold purpose.

Iowa is exceedingly fortunate in possessing rather extensive deposits of the so-called black diamond. The coal industry of the state is one of our principal industries, besides furnishing employment for more than 16,000 men annually. These rich deposits are conducive to the upbuilding of our manufactures, since cheap fuel is a requisite and valuable asset to extensive industrial growth. It is true that Iowa is generally known as an agricultural state, but she is steadily gaining prestige as an industrial commonwealth, for today Iowa-made products are to be found on the far side of the globe.

In his article Mr. E. A. Sayre gives us an insight into the nature and extent of our coal deposits; also the methods of mining the rock. It is hoped that in Iowa the practice of machine mining will be more extensively adopted in the future. This should result in the conservation of the smaller stratified coal veins that overlay the main deposit. By the present wasteful practice these smaller veins are destroyed, due to their cracking and caving after the main coal vein is removed and the mine abandoned. However, we realize the limits of our coal crop, and are bound to demand a more thorough system of mining before long.

The editor is indebted to Mr. C. Henry for the passage in the fore part of this number in which he so strongly visualizes "The Engineer." Through the courtesy of Mr. C. H. Mackintosh we are enabled to reprint this from the December number of Steam Machinery.

College Notes

A good portion of the equipment has been installed in the M. E. Laboratory, and is now being used. The department will experience no difficulty in the future providing plenty of laboratory work for those classified in Engine laboratory and Materials testing. In fact, there will be more equipment available than the student can find time to use, and in addition this will afford an excellent opportunity for research work. The addition of a post-graduate course to the present curriculum is contemplated to take advantage of the abundance of new and up-to-date equipment of the laboratory.

A man has at last been elected to take charge of the new courses in structural design. Allan H. Kimball, graduate in Architectural Engineering at the University of California, is the man. After graduating from California Mr. Kimball took post-graduate work at the Massachusetts Institute of Technology. He later spent several years in leading architectural offices. For the last year and a half he has been teaching at the University of Illinois. The class room work in structural design will commence about the first of March.

B. S. Myers, C. E. '10, has been chosen as assistant in structures. He will have charge of both class room and drawing room work. Mr. Myers, after graduation, took post-graduate work here in structures. He spent a year with the Des Moines Bridge & Iron Co., and was later in charge of a $25,000 contract in Los Angeles. Before coming to Ames he was employed as a designer by the Chicago, Milwaukee & St. Paul Ry. at Chicago.

The Senior Mechanicals and Electricals spent a very profitable week in Chicago and Milwaukee the latter part of January, inspecting some of the largest and most complete power plants and manufacturing establishments in the country. The occa-

sion was the fourteenth annual inspection trip in these courses. In Chicago and vicinity the Automobile Show, the Hawthorne works of the Western Electric Co., the Commonwealth Edison Power Co., two of the more notable pumping stations, the Indiana steel plant at Garry, and the Pullman Car Works at Pullman, Ill., were visited. In Milwaukee the party visited the plant of the Allis-Chalmers Co., the Kearney-Treckner Milling Machine Co., the Pawling and Harnischfey Works, Cutler-Hammer Co., and the city light company's plant. Twenty-five men, with three professors, took advantage of the trip, and all report a good time. At Chicago the Ames engineers of the city arranged a banquet for the inspection party. The students were privileged to meet some of the strongest engineers Ames has ever graduated, while the alumni in turn, received a better conception of what Ames is turning out today. There were nearly a hundred engineers at this banquet.

Alumni Notes

W. A. Scott, C. E. ex-'81, of Caldwell, Idaho, is now in charge of the Portland office of the "Engineer and Builder" of Seattle, Wash.

T. A. Noble, C. E. ex-'84, is now located at North Yakima, Wash., where he is developing his land interests. For a time he held the position of Chief Engineer for the U. S. Tieton Irrigation Project in Yakima county.

J. H. Mayne, C. E. '85, is engaged in civil engineering work at Council Bluffs, Ia. His specialty is drainage work. His wife, a former student at Ames, was Frances E. Verner.

J. H. Bramhall, M. E. '90, is joint proprietor of the Iowa Machinery & Supply Co., of Des Moines, Ia.

R. B. Benjamin, E. E. '92, is president of the Benjamin Electric Mfg. Co. The main office is in Chicago, with branch offices at New York, Toronto, San Francisco and London.

E. D. Jones, C. E. '92, is working for the government on the lower Mississippi. His headquarters are at New Orleans. He was recently in Washington, D. C. as an expert witness in a government case.

Frank Sexton, ex-'97, visited in Ames during the holidays. He is now City Engineer at Steamboat Springs, Colo.

J. N. Bonnell, E. E. '98, and wife, formerly Irene Jones of the same class, have spent the past year in France, where he went in the interests of the Automatic Telephone Co. They expect to return to America in the near future.

S. W. Farr, C. E. '98, is Chief Engineer for the Oliver Mining Co., at Duluth, Minn.

T. E. Nicoll, E. E. '99, who has been with the General Electric Co. for several years, is now located at St. Louis, Mo.

J. C. Austin, M. E. '02, is Manager of the Manufacturers' Service Bureau, with headquarters at 508 Ford Bldg., Detroit, Mich.

C. H. Streeter, C. E. '03, is City Engineer and Water Works Commissioner of Cedar Falls, Iowa.

C. W. Poland, C. E. '03, is Water Works Contractor and Engineer. His offices are in the Iowa Loan & Trust Bldg., Des Moines, Ia.

H. H. Knowles, Min. E. '04, is now in Texas waiting for the Mexican trouble to quiet down so that it will be safe for him to return to his mining work at Torreon, Mex., where he has been located for the past six or seven years.

M. L. King, M. E. '06, is Manager of the David Bradley Mfg. Works, at Bradley, Ill. The company is owned and operated by Sears, Roebuck & Co.

Arthur L. Sanford, M. E. '06, is with the B. F. Sturdtevant Co. of Chicago, Ill. Though Mr. Sanford has been in different locations, his connection with the company has been continuous since graduation.

J. C. Clark, E. E. '07, is Assistant Professor of Electrical Engineering at Leland Stanford Jr. University at Palo Alto, Calif.

F. V. Skelley, E. E. '07, is Assistant Superintendent of the Tri-City Ry. Co., at Davenport, Ia.

Stanley Macomber, C. E. '08, is City Engineer of Centralia, Wash. He has had charge of some large municipal projects.

R. W. Kindall, M. E. '10, is Superintendent of the Terre Haute branch of the Indiana Inspection Bureau.

Every Engineering student should read the Iowa Engineer every month. When our agent calls on you be loyal and give him your subscription.

THE IOWA ENGINEER

CONTENTS

PUBLISHED MONTHLY DURING THE COLLEGE YEAR BY

STUDENTS OF THE DIVISION OF ENGINEERING
IOWA STATE COLLEGE, AMES, IOWA

Annual subsription $1.00 Single Copies, 15 cents

Engineer's Joy

"Who draws a line and satisfies his soul,
Making it crooked where it should be straight?
An idiot with an oyster shell may draw
His lines along the sand, all wavering,
Fixing no point, or pathway to a point,
An idiot once removed may choose his line,
Straggle and be content; but, God be praised,
Antonio Stradivari has an eye
That winces at false work and loves the true,
With hand and arm that play upon the tool,
As willing as any singing bird
Sets him to sing his morning roundalay,
Because he likes to sing and likes the song."

"The spirit expressed by the great violin maker underlies all success.

The engineer must unite that strength of character which every leader must possess, with good sense, such as all men commanding the respect of their fellows must exhibit, with integrity such as no man can advance without, through professional education and training such as is always essential to professional success

It is certainly true that the intellectual training of the engineer furnishes larger opportunity and greater capacity for intellectual enjoyment than is possible from any purely "cultural" education. Nevertheless, he, to secure highest results, must make himself a liberally educated man; must attain wisdom as well as culture, learning as well as technical knowledge, if he is to meet all men on a common and lofty ground.

He must combine the attributes of the gentleman and scholar with those peculiar to his profession."

ROBERT H. THURSTON.
Dedication Address, Engineering Hall.

By W. H. MEEKER*

*Professor of Mechanical Engineering.

VOL. XIV. MARCH, 1914 NO. 6.

Oil-Friction Testing Machine

J. G. HUMMEL*

The properties which are usually determined in studying a given sample of lubricating oil are, viscosity, flash-point, burning-point, and specific gravity. Sometimes other of its properties are determined but not often is any attempt made to learn its coefficient of friction. The reason for this is, that the machines designed for this purpose have proven more or less unsatisfactory and not because this property is of secondary importance. With the machines commonly used in laboratories it has been very difficult for different experimenters to check each other's results or even for one experimenter to get consistent results. The property itself, coefficient of friction, is of the utmost importance, for an account of it, and it alone, depends whether the friction loss in a machine is large or small. In some special cases, for instance in a gas engine cylinder, the conditions to be met are such that the frictional property does not control but the oil must offer lubrication at the extreme temperature in the cylinder without decomposing into objectionable deposits. Other special examples might be cited but by far the largest number of bearings to be lubricated are those for which the frictional property of an oil should control.

*Assistant Professor in Mechanical Engineering

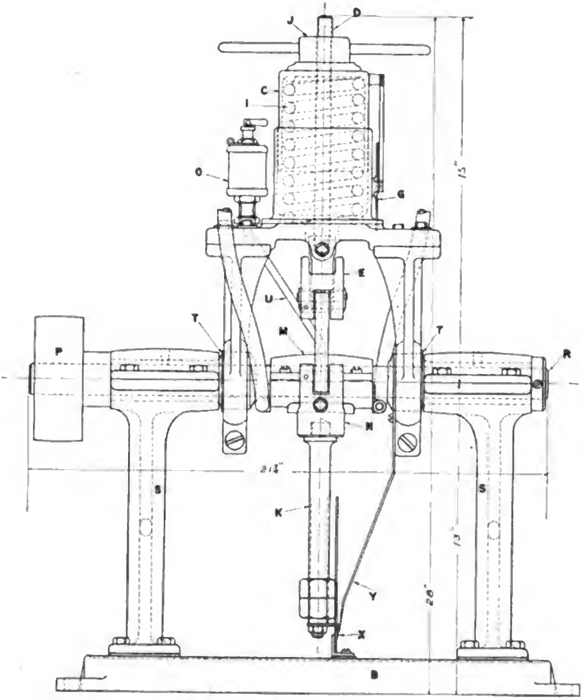


Fig. 1

figures, B is a base casting. S and S are standards carrying the trunnions T and T. The friction shaft has its supporting bearings in the trunnions T and T and it is driven by the pulley P. The whole upper part of the machine is bridged across and supported entirely on the trunnions on which it is free to swing concentric with the shaft R. This bridge carries the telescoping spring case C, which contains a compression spring I. As the spring is compressed the relative motion of the parts of the

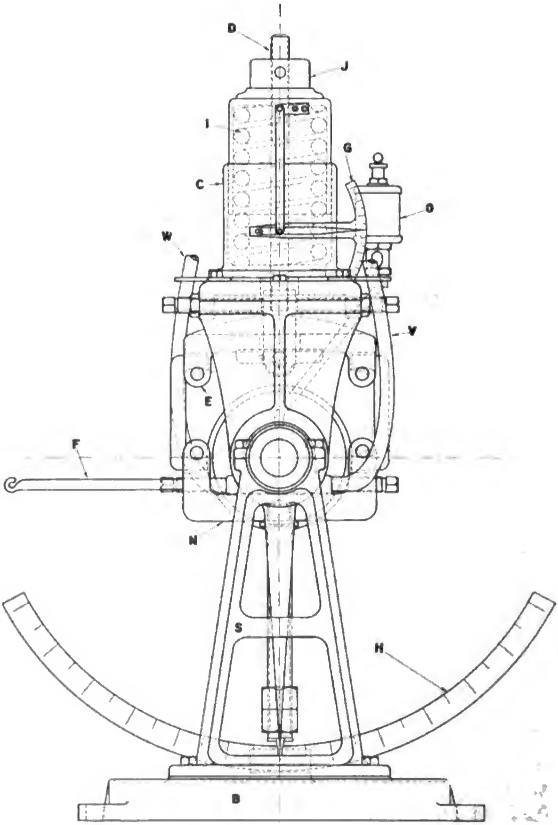


Fig. 2

spring case operates the multiplying index pointer which plays over the graduated segment G, this segment reading pounds load on the spring. A draw bolt D threaded at its upper end and fitted with a capstan nut passes down through the spring case and bridge and on its lower end is a loop in which the center knife edge of the equalizer is carried. M is the test bearing and it is supported on a sort of stirrup N, which hangs from the two end knife edges of the equalizer E. The pendulum rod K is fastened rigidly to the test-bearing support N.

The lower two-thirds of this rod K is threaded and carries auxiliary weight locked between the two standard nuts which are shown. The position and amount of this weight determining the sensitiveness of the machine. Figure 3 is a line drawing of the equalizer E and the test-bearing M and its supporting stirrup N. The center knife edge of the equalizer E is carried in the loop at the lower end of the draw bolt D. The test-bearing support N is carried on the end knife edges of the equalizer. The bearing points of this system of support which have any relative motion due to the swing of the pendulum are all knife edges reducing the friction relative motion to a minimum. The three knife edges of the equalizer are in a straight line so that angularity does not change the relative lengths of its lever arms. For similar reason the two knife edges of the test-bearing stirrup are on a straight line with the center of the friction shaft. The center knife edge of the equalizer and the test-bearing are each made adjustable as to their position between the end knife edges so that they may be located centrally after the parts are finished and assembled. The pendulum rod K carries at its lower end a pointer X which plays over the arc H as the pendulum swings. H is graduated in degrees. Fastened to the housing of the bridge is a second pointer Y which registers with the pointer X when the line of pull of the draw rod D coincides with a line through the center of gravity of the pendulum and the center of the shaft. When these two lines coincide and are in a perpendicular, then X and Y are at zero on the arc H. No matter what position the pendulum may take if Y is made to coincide with X, then the line of pull of the draw rod D coincides with the line through the center of gravity of the pendulum and the center of the shaft and there is no moment due to this

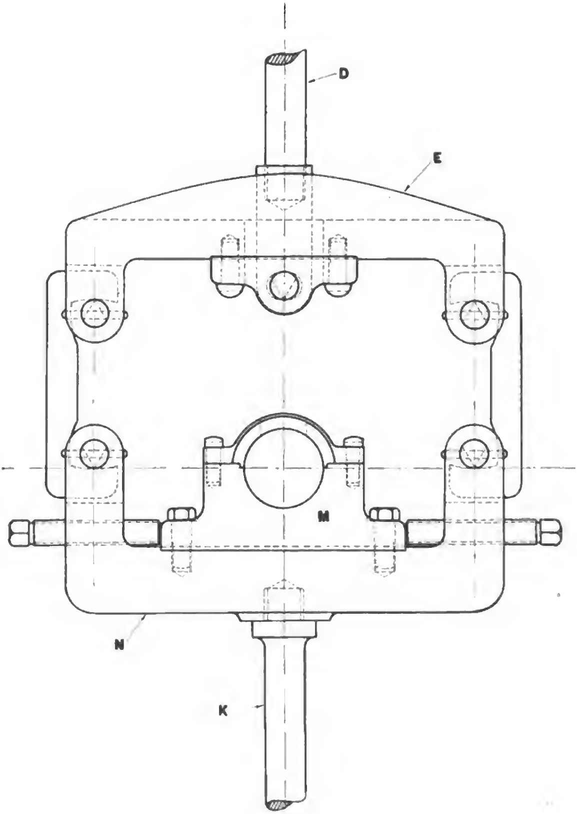


Fig. 3

pull tending to swing the pendulum about the shaft. When the shaft is rotating and there is some load on the test-bearing the pendulum will swing in the direction of rotation of the shaft by virtue of the freedom in the equalizer. If now Y is made to register with X by swinging the housing about the trunnions as axes, then the pendulum must be held in this angular position by a frictional moment in the test-bearing which is sufficient to balance the counter moment of the weight of the pendulum acting through the center of gravity.

If we know the weight of the pendulum and the distance from the center of the shaft to the center of gravity, then for any angular position we can readily calculate the moment that is tending to bring the pendulum back to the vertical. Then the frictional moment in the bearing must equal this moment because these are the only unbalanced moments acting at this position so they must balance. The frictional moment is the frictional force multiplied by its lever arm, the radius of shaft, and the frictional force is the normal pressure multiplied by the coefficient of friction so that if we know the value of this frictional moment and the load on the bearing we may calculate the coefficient for that particular condition. By the principles of Mechanics we write the summation of moments about the center of the shaft for the pendulum considered a free body.

$$Fr.-G\,x\,\sin a=o \qquad \text{..........1.}$$

in which F is the frictional force acting on the surface of the bearing and r the radius of the shaft. G is the weight of the pendulum parts, x the distance of its center of gravity from the center of the shaft and a the angular displacement. The moments created by the pulls in the two draw links were omitted from the above equation because they neutralize each other as previously stated. If for F we write Pf, where P is the load on the bearing and f the coefficient of friction and solve equation 1 for f, we have

$$f=\frac{G\,x\,\sin a}{Pr} \qquad \text{..........2.}$$

All the quantities in the second member of equation 2 are known or can be observed thus enabling us to calculate f. x can readily be determined as follows: Rotate the bridge housing and pendulum until they are horizontal and support the pendulum

on a balance at a measured distance b from the center of the shaft. With a low pull on the bearing, say 100 pounds or just enough to keep the parts in their normal positions, rotate the shaft upward on the pendulum side and read the weight on the balance calling it W'. Reverse the direction of rotation of the shaft keeping speed, pull and other conditions as before and again read weight on the balance calling it W". Since the conditions have remained constant except direction of rotation, we may assume that the frictional force between the bearing and the shaft has the same numerical value but simply reversed in direction. The pulls in the supporting links neutralize each other as before and writing the summation of moments about center of shaft for each of the above cases omitting the link pulls, for first case

$$Fr + W'b = Gx \quad \ldots\ldots\ldots\ldots 3.$$

for second case

$$-Fr + W''b = Gx \quad \ldots\ldots\ldots\ldots 4.$$

adding and solving for x

$$x = \frac{W' + W''}{2} \cdot \frac{b}{G} \quad \ldots\ldots\ldots\ldots 5.$$

Knowing W', W", a, and G, x can be calculated and becomes a known quantity to be substituted in equation 2.

In making a friction determination we proceed as follows: The segment G on the spring case being calibrated to read actual total load on the bearing, we set the index at some particular load call it P. The shaft is revolved clockwise at say 500 r.p.m. The index X swing clockwise ahead of Y. If now Y is made to register with X we read a directly on H. To correct for any inaccuracy in adjustment, we observe the angular displacement on the opposite side and use the average angle for our calculation. The sine of the angle with P the load on the bearing and the other known quantities substituted in equation 2. gives the coefficient of friction f which is desired.

In this machine the distortion of the spring used to load the bearing does not shift the center of gravity of the pendulum as this action does in many machines. Neither does the amount of oil in the oil cup or the shifting of this oil due to angular position shift the center of gravity. There is a slight chance

for shaft deflection but no evidence of this has been observed in the wear of the bearing. With the bearing cap in place during a test the pull of skin friction of the oil on this cap is added to the true friction force due to the load on the bottom half of the bearing to cause angular displacement of the pendulum. This skin friction is appreciable as evidenced by the results obtained by making observation with or without the cap, other conditions remaining the same. The lower half of the test-bearing is made with thick walls as shown in figure 4 and six

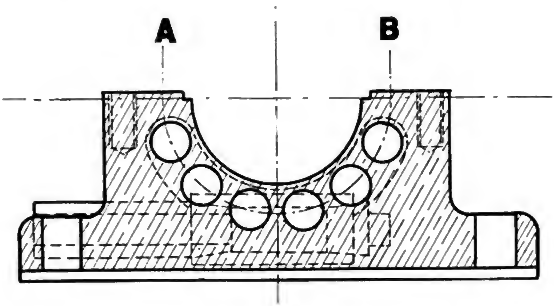


Fig. 4

quarter inch holes are drilled parallel to the axis and the side of the hole being 3-32 of an inch from the surface of the bearing. Figure 5 shows a development of this system of holes and the method of porting. Water is supplied through a rubber hose at 1 and follows two separate similar passages and leaves at 2 through a rubber hose. A thermometer is inserted through the gland 3 directly into the exit water. With a generous supply of water the bearing surface temperature can be but little different from that of the out going water. The calibrations were made with the hose connected and water flowing.

The machine as set up for use is driven by a single phase, 220 volt, A. C., variable speed, reversing motor. The speed is varied by an auto-transformer and controller; the controller having thirty running points for either direction.

The speed is further controlled by inserting in the circuit a

rheostat so that any speed between those given by the regular controller may be obtained. The speed may be anything up to 1000 r.p.m. A thousand revolutions gives a surface speed of 314 feet per minute. The load on the bearing may vary up to 150 pounds per square inch of projected area. The jacket water may be controlled between ordinary temperatures and 212° F. The oil is drop fed onto the shaft. With all of these conditions under our control we may make determinations for almost any combination of conditions that are liable to be met with in practice. The most common combination is the relation between coefficient of friction and intensity of pressure other conditions remaining constant; or between coefficient of friction and surface speed, other conditions constant.

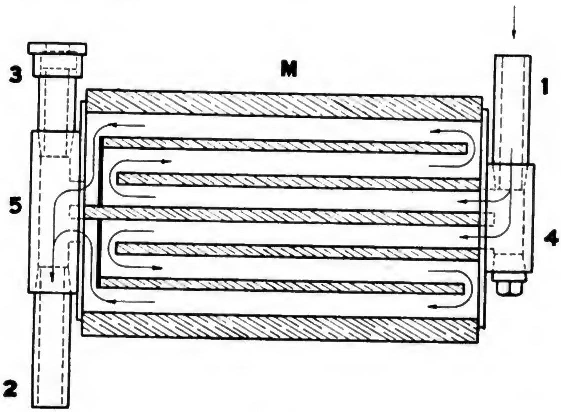


Fig. 5

It is not the object of this article to give results of elaborate tests of oils but rather to show that the machine is capable of giving quite consistent results under trying conditions. It has been subjected to the hardest sort of trial and the accompanying curves will testify as to how well it has stood this test. The first tests made upon it, were made by the classes in the regular Mechanical Engineering Laboratory work by Junior Engineer-

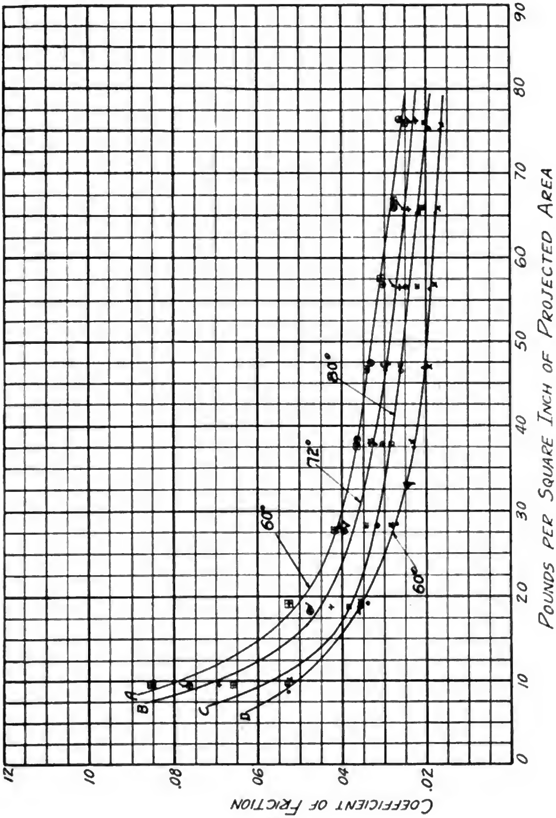


Fig. 6

ing students. Sections of these students coming into the laboratory on different periods were asked to go through a complete

calibration as outlined above and then for a particular oil or oils were required to determine its coefficient under different imposed conditions. The results obtained by eight different sets of students working on different days have been plotted in curves shown in figure 6. The curves A, B, and C are for a steam engine cylinder oil, and D is for a machine oil. The different curves were for the various temperatures indicated. Each curve is drawn as an average of two sets of points, the values for which were determined by two different sets of students. The surface speed was about 125 feet per minute in each case. Many other tests made entirely by students in the regular laboratory work are as consistent as these shown in figure 6.

The machine is of a relative small size: the shaft is 1¼ inches in diameter; but there should be no reason why a machine of a larger size constructed on the same principle as this small machine would not give as consistent results.

Growth of Metric System.—The fifth general conference on the metric system, which opened at Paris late in 1913, discussed the problem of internationalizing weights and measures. A dozen important countries have passed laws compelling the use of metric system since the last conference. Denmark, China, Japan, the five republics of Central America, Bulgaria, Chile, Uraguay and Siam have fallen in line. The first British colony to adopt the metric system in its entirety is the Island of Malta.

In all that you do, remember that you have the reputation of the greatest of all professions to uphold, that your integrity must ever be beyond question, and that there is never an excuse for untruth of any kind. Business shrewdness is all very well in its way, especially for those who go into contracting, but falsehood is always needless.—*Waddell.*

It ought to be the incessant aim of the organizers of technical schools and classes to broaden the basis of instruction and to fight against the narrowing tendencies abroad. But this must not be done without discrimination.

A Novel Method of Plotting Granulithic Analyses of Sand and its Application to the Proportioning of Surface Mixtures for Asphalt Pavements

GEORGE R. CHATBURN*

Several years ago the author devised the method of plotting given below for the purpose of recording and comparing some sand analyses which he was making. Later he suggested the method to Professor C. E. Mickey of the University of Nebraska, who used it with manifest success in grading mixtures for asphalt paving. Other engineers are looking upon it with favor. Believing that it can be expanded and become of considerable practical value the author wishes to place it in the hands of students interested in this line of work. This article for the Iowa Engineer furnishes the opportunity.

When a definite grading has been determined upon it is plotted as a straight line; other gradings then plotted upon the same diagram are easily compared with this. To fix the attention the following standard grading is assumed:

STREET ASPHALT SURFACE MIXTURE.

		Sand alone	
Bitumen	10.5%		
Thru 200—mesh Sieve	13 %	14.5%	14.5%
Thru 100—mesh Sieve	13 %	14.5%	29 %
Thru 80—mesh Sieve	13 %	14.5%	43.5%
Thru 50—mesh Sieve	23.5%	26.3%	69.8%
Thru 40—mesh Sieve	11 %	12.3%	82.1%
Thru 30—mesh Sieve	8 %	8.9%	91 %
Thru 20—mesh Sieve	5 %	5.6%	96.6%
Thru 10—mesh Sieve	3 %	3.4%	100 %

The first column of figures shows the pre-determined mixture, usually given in the engineer's specifications; the second column the separations in percentages of the sand, including the filler; the third shows the percentages of sand finer than the corresponding sieve number—this last column is the one that is plotted.

*Professor of Applied Mechanics and Machine Design, University of Nebraska, Lincoln, Nebraska.

METHOD OF PLOTTING.

Upon a piece of cross-section paper, or paper ruled in one direction only, draw any convenient sloping straight line; *AC*, Fig. 1. This line will be the plot of the predetermined standard. The height of the diagram, *AD*, is divided into 100 equal divisions, the horizontal ruled lines may be used for this, and a scale marked on the left hand side. Going up this side to a point represented by the percentage of sand passing the 200-mesh sieve, in this case 14.5, a horizontal line *EF* is drawn to meet the sloping line, the standard curve, and through the intersection a vertical line *FH*. This vertical is marked 200 on

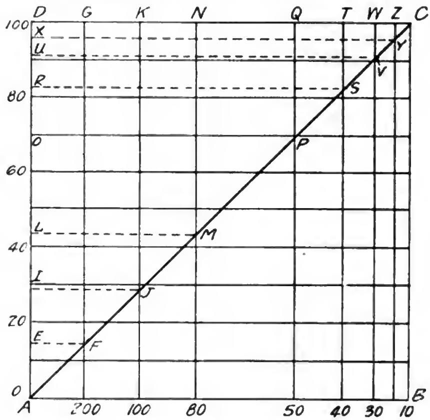


Fig. I. Diagram for plotting sand and analyses curves.

the diagram. Again at 29% a horizontal line *IJ* is drawn; this determines the 100-vertical. And so on for each of the other sieves; as many verticals being drawn as separations are desired.

To compare any other sand with this standard sand the separations are made in the usual manner by weighing out of a representative sample 100 grams, sifting in the finest sieve and recording the weight of the residue as in the second column of Figure 2, or by weighing that which passes as in the fourth column;

from either of these two columns the third may be calculated. The residue is placed in the next coarser sieve and the operation repeated until all sieves have been used. Figure 2 shows how the results may be recorded upon a slip of paper which can be filed for reference. Having these data for several samples of sand they are plotted by using the percentages in the column marked "passing" as ordinates and the verticals already drawn for the several sieves as abscissas. The actual work of plotting can be done very rapidly. In Figure 3 is plotted the standard, that is, the straight line curve, and the analyses of three other sands given in Table I.

SAND ANALYSIS

Lab. No. 123 Date 7/23/11

Missouri River

Sieve	Residue	Passing	Separation
200	81.0	19.0	19.0
100	20.0	79.8	60.8
80	11.2	88.4	8.6
50			
40	1.8	98.2	9.8
30			
20	1.0	99.0	0.8
10	.0	100.0	1.0

Characteristic, Round, soft, mostly quartz, a little feldspar and mica

Analysis made by A.B.C.

Fig. 2. Slip for keeping sank analysis data.

COMPARISON.

The curves, Fig. 3, immediately show the Platte River Fine, Curve *B*, to be the nearest to the standard adopted. It is lacking in the 200-mesh grains, but for asphalt paving that is desirable

as stone dust or Portland cement can be added and these make a better filler than fine sand or silt. It shows an excess of the 100-, 40- and 20-mesh separations; but on the whole would answer very well for a surface mixture.

TABLE I.

Sieve	Missouri River	Platte R. Fine	Platte R. Coarse	Standard
200—mesh	19.0%	8.0%	0.5%	14.5%
100—mesh	79.8%	35.4%	7.8%	29.0%
80—mesh	88.4%	42.6%	12.2%	43.5%
40—mesh	98.2%	91.2%	48.0%	82.1%
20—mesh	99.0%	97.0%	76.2%	96.6%
10—mesh	100.0%	100.0%	100.0%	100.0%

SYNTHESIS.

Suppose, however, this sand were not available, or somewhat more expensive than the other two varieties. Then the problem is to combine them so as to compose a working sand. If the

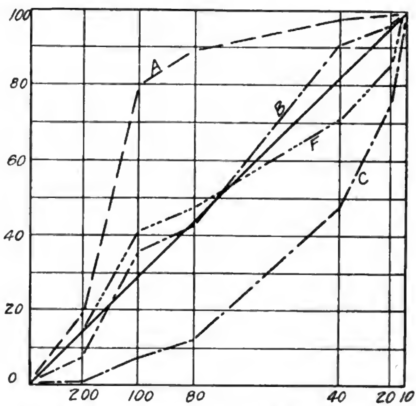


Fig. 3. Plots of sand analyses. A, Missouri River Sand; B, Fine Platt River Sand; C, Course Platt River Sand; F, a combination of sands A, C, and stone dust.

plots be noticed it can "by eye" be guessed that it will take about one and one-half parts of Platte River Coarse to one part of Missouri River to make them meet the standard along the

80-sieve vertical. If greater accuracy be desirable, let x represent the number of parts of the former to be taken for each part of the latter, then,

1 part of M. R. at 88.4

and

x parts P. R. at 12.2

Make

x+1 parts combined at 43.5

or expressed algebraically

$$88.4+12.2x=43.5\ (x+1).$$

Solving

$$x=1.43$$

The sands at the mixing plant are usually placed in separate piles and shoveled into the "cold sand elevator" by taking one shovelful of one kind, two of another, and so on. Now, one part Missouri River to 1.43 Platte River Coarse does not differ greatly from the guessed proportion of 2 parts M. R. to 3 parts P. R.; also it is nearly the same as 4 parts M. R. to 5 parts P. R. These are proportions that could easily be maintained by the shovelers. Of course the man in charge will check the mixture frequently as it comes hot from the dryer. In most plants the sand must be properly mixed before it goes into the dryer or it never will be right. If it were possible to separate the sand into as many grades as are used in making up the standard grading the "mix" might always be kept ideal; this, however, at present, seems impracticable.

Taking these proportions percentages are computed as given in Table II.

TABLE II.

Combination *D*, being 2 parts M. R. to 3 parts P. R.

Sieve	2 parts M.R.	3 parts P. R.	Sum.	D.
200—mesh	38.0 %	1.5 %	39.5 %	7.9 %
100—mesh	159.6 %	23.4 %	183.0 %	36.6 %
80—mesh	176.8 %	36.6 %	213.4 %	42.7 %
40—mesh	196.4 %	144.0 %	340.0 %	68.1 %
20—mesh	198.0 %	228.6 %	426.6 %	85.3 %
10—mesh	200.0 %	300.0 %	500.0 %	100.0 %

Combination *E*, being 4 parts M. R. to 5 parts P. R.

Sieve	4 Parts M. R.	5 parts P. R	Sum	F
200—mesh	76.0%	2.5%	78.5%	8.7%
100—mesh	319.2%	39.0%	358.2%	39.8%
80—mesh	353.6%	61.0%	414.6%	46.1%
40—mesh	392.8%	240.0%	632.8%	70.3%
20—mesh	396.0%	381.0%	777.0%	86.3%
10—mesh	400.0%	500.0%	900.0%	100.0%

These two gradings, combinations *D* and *E* are plotted in Figure 4. It will be noticed that they follow the standard about as well as the Platte River Fine, Fig 3, *B*. It yet remains to obtain the quantity of filler to be added to bring that part of the sand smaller than the 200-mesh up to the standard.

Curve *B*, Fig 3, is too high in the coarse part: the addition of filler will make it still more so. Curves *D* and *E*, Fig. 4, are low in the coarse part so they can carry considerable filler, a

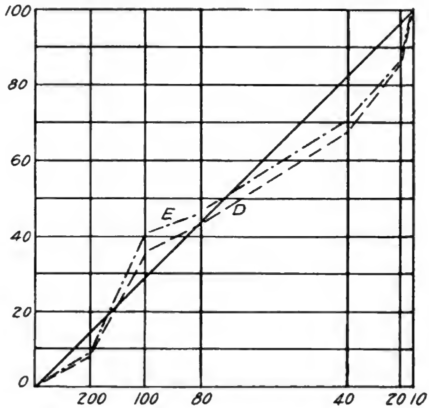


Fig. 4. Plots of combinations of sands A and C, Fig. 3; D, two parts of A and three parts of C; E, four parts of A and five parts of C.

most desirable thing. The only trouble being the quantity of 100-mesh grains will become excessive, but that is not so very bad a fault as the fine sand prevents the "balling" of the stone-dust, and the "asphalt" rakes much smoother on the street.

Adding enough stone-dust to bring the 200-mesh material, combination *D*, Table II, to the standard, 14.5%, will require, providing the dust sifts as follows: through 200-mesh, 80%; 100-mesh, 90%; and 80-mesh, 100%,

$$\frac{100\ (7.9+80\%\ Q)}{100+Q}=14.5$$

whence,

$$Q=10.1$$

Adding this the grading becomes for combination *F*.

200—mesh	7.9% + 80% of 10.1% = 16.0%	or 14.5%
100—mesh	36.6% + 90% of 10.1% = 45.7%	or 41.5%
80—mesh	42.7% + 100% of 10.1% = 52.7%	or 47.9%
40—mesh	68.1% + 100% of 10.1% = 78.2%	or 71.0%
20—mesh	85.3% + 100% of 10.1% = 95.4%	or 86.6%
10—mesh	100 % + 100% of 10.1% = 110.1%	or 100.0%

This grading is plotted as curve *F*, Fig. 3.

This practically completes the sand determination unless the asphaltic cement used runs high in mineral matter. In such a case a correction must be made for that, and possibly less filler used.

GREATER CONFORMITY

Should it be desired to make both asphaltic cement and 200-mesh material correspond closely with the standard, two equations containing two unknown quantities may be used and these solved simultaneously for the unknowns. Thus using combination *E* for an example and assuming the *A. C.* to contain 20% mineral matter all passing the 200-mesh sieve and the stone-dust as above, these equations result:

$$\frac{100\ (80\%\ A.\ C.)}{100+20\%\ A.\ C.+S.\ D.} = \frac{100\ (10.5)}{89.5}=11.7$$

$$\frac{100\ (8.7)+20\%\ A.\ C.+80\%\ S.\ D.}{100+20\%\ A.\ C.+S.\ D} =14.5$$

Clearing of fractions

$$77.7\ A.\ C.-11.7\ S.\ D.=1170$$

$$17.1\ A.\ C.+65.5\ S.\ D.=580$$

Solving for the asphaltic cement, *A. C.*, and the stone-dust, *S. D.*, gives, using slide rule computation, which is close enough.

$$A.\ C.=\frac{\begin{vmatrix}1170 & -11.7\\ 580 & 65.5\end{vmatrix}}{\begin{vmatrix}77.7 & -11.7\\ 17.1 & 65.5\end{vmatrix}}=\frac{76600+6800}{5089+200}=15.8$$

$$S.\ D. = \frac{\begin{vmatrix} 77.7 & 1170 \\ 17.1 & 580 \end{vmatrix}}{\begin{vmatrix} 77.7 & -11.7 \\ 17.1 & 65.5 \end{vmatrix}} = \frac{45100-20000}{5089+200} = 4.7$$

The complete mixture then becomes:

Sieve				G	Standard
Bitumen	80% *A. C.*		12.64%	10.5%	10.5%
200—mesh	100% *A. C.*	15.8%			
	80% *S. D.*	3.8%			
	Sand	8.7%	28.3 %	23.5%	23.5%
100—mesh	100% *A. C.*	15.8%			
	90% *S. D.*	4.2%			
	Sand	39.8%	59.8 %	49.6%	36.5%
80—mesh	100% *A. C.*	15.8%			
	100% *S. D.*	4.7%			
	Sand	46.1%	66.6 %	55.3%	49.5%
40—mesh	*A. C.* + *S. D.* + Sand		90.8 %	75.3%	84.0%
20—mesh	*A. C.* + *S. D.* + Sand		106.8 %	88.6%	97.0%
10—mesh	*A. C.* + *S. D.* + Sand		120.5 %	100.0%	100.0%

The next to the last column, combination *G*, and the last column, the standard inserted for comparison, are plotted in Fig. 5.

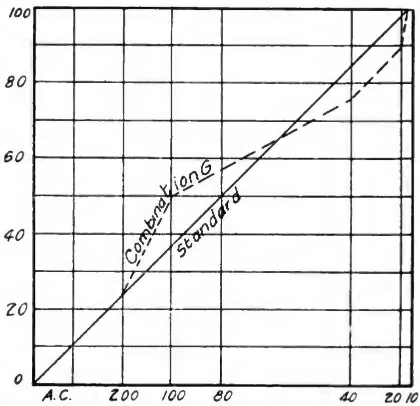


Fig. 5. Plot of combination G, being sand E after the asphaltic cement and stone-dust has been added to bring it in harmony with the standard adopted.

Still closer conformity might be accomplished by using more sands and more unknowns and solving the equations algebraically; but as the sands used are not uniform it would be impractical to be continually performing long algebraic operations, especially as close enough conformity may be obtained "by eye" from the plotted curves and slight changes can be made from time to time as are shown to be necessary by testing the output. Fig. 6 shows two pages of Professor Mickey's note book as used in daily practice.

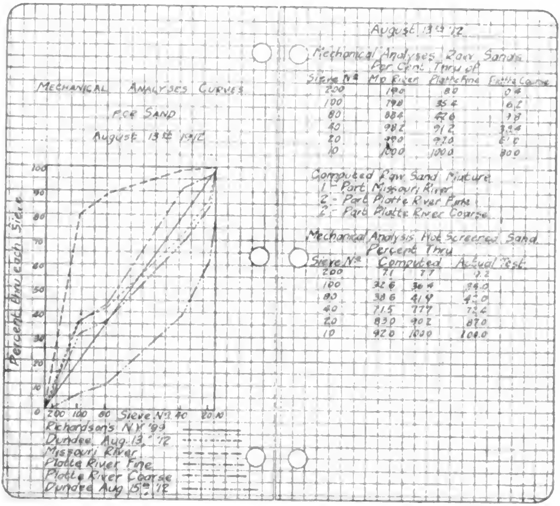


Fig 6. Two pages from Mr. Mickey's note book as actually kept by him on paving work at Dundee, a suberb of Omaha, Nebraska. The last two columns show how closely the hot mixed sand conformed with the computed mixture. The size of the pages is 3¼ x 6¼ inches.

ADVANTAGES.

Some of the advantages of this method of plotting are:

1st. The standard grading is a straight line which is very easily plotted.

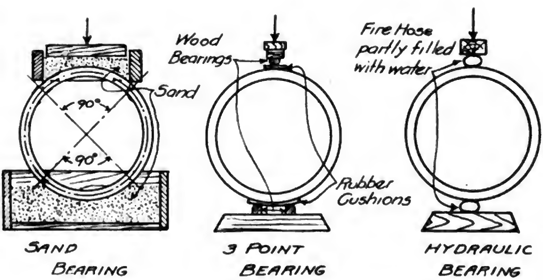
2d. The verticals being drawn for the sieves, plotting the analysis of any other sand is quickly accomplished.

3d. Comparisons are readily made; the eye noting instantly the relation of the several sands to the standard or straight line.

4th. In synthesizing sands the proportional parts may be estimated by eye to a reasonable degree of accuracy.

5th. Emphasis is placed on the part of the plot representing the fine sand instead of that part representing the coarse as in the ordinary method of plotting. The fine sand is of great importance in asphalt paving on account of its proportionally great surface and consequent asphalt carrying power.

6th. The graphical charts when kept in a loose leaf note book serve as a permanent record and in case of reference additional or re-calculations are not necessary.



The above illustration is substituted as a correction for a similar illustration that appeared in January issue in connection with the article "Specifications and Tests for Drain Tile." The bearings in second and third method are wood and hose filled with water as shown here, and not metal and hose filled with sand as shown before.

Every man is my master in something; this I endeavor to learn from him.

Some Results of Engineering Extension

K. G. SMITH*

Extension work in agriculture or engineering which deals directly with the manufacturer and producer has its results measured in dollars and cents, or what is the same thing, in increased productive capacity. The results may be direct or indirect, but in the end they can be definitely and tangibly shown. The employer measures the value of engineering extension so far as it relates to him by the degree in which it enables him to come in touch with better methods and to obtain, keep, and develop efficient workmen. The workman almost invariably measures its value to him in just one way, increased earning power, and the more immediate this result, the better. As his interest increases, however, by reason of results obtained, he becomes more willing to study subjects whose immediate usefulness is not so apparent, but which indicate possible lines of development for him in the more distant future.

RESULTS FROM THE EMPLOYER'S STANDPOINT.

Employers as a general rule are harder to educate than employes. In the city of Milwaukee, five years ago, it was with difficulty that a concession of one hour for study every two weeks on company time was granted to men taking engineering extension courses. A year later several employers in view of results obtained voluntarily offered to grant one hour every week to their men for study. Two years later three large concerns voluntarily granted five hours a week to their apprentice boys and one hour per week to journeymen. The final result of this work is the present system of continuation schools in Milwaukee and throughout Wisconsin. The fact that more and more time was granted by employers for study indicates clearly that they were getting returns in increased efficiency.

One employer in whose plant classes had been running for three years said, "I used to go to Cincinnati for my foremen, now I train my own." Another one after trying the plan four months said, "I see the difference in my men already." One manager of a very large plant said, "The work furnishes me an excellent sieve. Any man thus sifted out, I keep my eye on.

*Professor of Engineering Extension, Iowa State.

We need him." Time and again the writer has been asked to recommend men from classes for advancement and in no case has a man thus recommended failed to make good. It must be said however, that actual grades obtained in class are by no means the chief basis for such recommendations. In one case two men were recommended for foremen's positions from a class of fourteen. One stood at the head of the class and the other third from the foot. Both had been developed by the work and both made good.

RESULTS FROM THE WORKMAN'S STANDPOINT.

That workmen better themselves by study goes without saying and to enumerate examples of salaries raised and benefits derived would savor of patent medicine advertising. A few however, may not be out of place.

(1) A boy employed as a helper gradually worked up through the shop printing office, blue print room, and drafting room and is now in the designing office of a large concern. This boy studied faithfully for nearly five years beginning with the most elementary work.

(2) A foundry apprentice developed considerable skill as a draftsman and on finishing his time went into the drafting room and is now employed as a designer on foundry work.

(3) Cases of machinists, pattern makers and molders becoming foremen have been numerous. Others have become more efficient in their work, for the effort is not to educate a man *out of* but *into* and *for* his work. One gas engine man says after four months study, "I now figure out my gasoline for a test. Before it was by guess and by God." Another says, "I wish I could have had this course before, so that I could be using it instead of getting it."

Habits of study and reading have been formed leading the man beyond the bare weekly lesson. In one industrial center where the class met in the library, the circulation of industrial books doubled in one year due to the increased interest in study. In another city branch stations were established in different shops, through the efforts of the local instructor. At one of these, twelve out of fourteen books were in circulation all the time.

Most boys have little opportunity to see and study shop

processes outside their own shop or department. The writer has had classes of apprentice boys who would put many college men to shame in "seein' things" on a shop trip and in describing and sketching as well. One group of twelve spent two hours in a comparatively small shop and asked that on the next trip they might start early, go to the same place, and spend a whole half day there. Reports of progress to employers are productive of results. A man who knows that his employer is interested in him stays with him for the very good reason that he sees a chance of advancement. The employer therefore has a steadier and more loyal workman. The teacher often persuades boys to "stay with it" even through discouragements for the sake of promotion which to them seems slow in coming. One young man of the writer's acquaintance, slow in his studies, stuck to a monotonous job for two years because of the opportunities for study, offered by his employer. At the end of that time he became foreman and later superintendent of his department. Three times in the two years he would have quit had it not been for the encouragement given by his instructor. Another man was warned that owing to his carelessness an adverse report might go in to "the boss." He remarked, "Hold it up. I'll do better; I wouldn't have that go in for ten dollars."

No one who has worked with and taught shop men and boys, who has seen their ambition kindled and intense earnestness shown and mechanical ability developed ever doubts the results of engineering extension. The relation of teacher and student is far different from that of the college man and his teacher. Between the extension teacher and his student there exists a feeling of equality, friendship and "cameraderie" unknown elsewhere. Discipline rarely if ever enters in.

ENGINEERING EXTENSION AND INDUSTRIAL EDUCATION.

No doubt someone will say that the above results are the results of industrial education, not of engineering extension. Engineering extension is or has been up to the present time largely industrial education. More advanced courses are being called for and developed but their results are not so easily shown and the writer's experience has been more limited in this line. The vast bulk of our engineering data needs to be interpreted and brought to the man on the job. When traveling for

the experiment station of the University of Illinois the writer found a young draftsman studying over one of the experiment station bulletins. On inquiring as to where he obtained it his reply was, "The boss gets 'em and fires 'em in the waste basket and I fish 'em out." Isn't it about time we ceased to sprinkle all our technical instruction over the top and begin to pump some up from the bottom? When we do, there will be some results in engineering extension proper as well as in industrial education. An experiment station without an extension department is like a manufacturing plant without a sales organization. "Direct to consumer" has a meaning here as well as in commercial lines.

No more effective way of teaching a lesson or of driving home a point could be devised than that so frequently adopted by *Power* of printing a cartoon on its title page. One of these is now before us. It depicts the president of an industrial plant, seated in his office. The engineer stands before him, his whole attitude indicating perplexity, if not actual doubt. The "boss" has just announced that the present plant, with its antiquated equipment, is going to be torn out to make way for a first-class up-to-date plant, and the engineer has been asked the question: "Could you handle that type of plant?" Why does the man hesitate in giving an affirmative answer? He has not made himself ready for the next step. He has not kept abreast of advancement in his field. Keeping ready for the next step is one of the surest indications of efficiency in any man, no matter what the nature of his work. The next step is sure to come, often it comes unexpectedly. If the man in line is not ready to take it, some other man is. The higher place goes to the man whose foot is prepared to advance at the first word of command. Keep yourself always in full marching order and there will be no doubt or perplexity or hesitation when you hear the call: "Forward."—*Valve World.*

Errors like straws float upon the surface. We must dive deep to find the pearls.

Exterior view of the construction of State Penitentiary at Fort Madison. Fremont Turner, B. M. E. '79, engineer in charge.

Water Works Dam, Oklahoma City, Okla. Construction across the North Canadian River, south of water works pumping station. Designed and built by M. J. Reinhart, B. C. E. '05 and D. E. Donovan, B. C. E. '03.

THE IOWA ENGINEER

Published Monthly During the College Year by the Students of the Division of Engineering, Iowa State College, Ames, Iowa

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EDITORIALS

There is now in the equipment of the new mechanical laboratory a rather small, yet not insignificant, machine, that should prove of considerable service to the mechanical world. The oil friction machine recently perfected by Prof. Hummel is not essentially a new idea, but is the realization of results at which others have aimed for some time.

This machine, an interesting description of which is given by the designer elsewhere in this issue, is the outcome of experience gained previously in the construction of some three such machines that were more or less similar in working principle. It was his aim from the outset to perfect a machine that would exactly duplicate working conditions imposed on a bearing. In pursuance of this idea the machine was constructed with a re-

movable test bearing, thus enabling the substitution of any type of standard bearing for test purposes. In addition care was taken to apply the load to the bearing exactly as it is applied in an ordinary machine or line shaft bearing, namely, to the lower half. To our knowledge, this machine approaches more nearly conditions as actually met with in practice than any other such machine in existence today.

The value of this simple little machine is at once apparent, when we consider the vastness of its application. Nearly every piece of machinery requires a lubricant of some sort. Prior to this time there existed no really accurate method for ascertaining just what grade of oil is best adapted to a particular service, except by trying out various grades, and this scheme is by no means accurate. The determining quality generally is,—what is the coefficient of friction of the oil in question? Heretofore it was impossible to better than roughly approximate this by such indirect methods as flash-point, and viscosity. The oil tester now enables one to knowingly select the best oil by a process of elimination. It gives us the quality of an oil more eagerly sought yet seldom obtained with any degree of certainty.

We wish to call attention here to the article by Mr. George R. Chatburn, describing his new method of plotting the granulithic analysis of sand. Simpler methods of plotting such analysis will undoubtedly be welcomed by engineers. This method has an advantage over those in common use, first in plotting the definite grading of sand or fine materials, which is represented by any simple, sloping straight line. Then the analysis of the available materials for a job can be plotted on the same sheet. Mere inspection with the eye will then tell, accurately enough for all practical purposes, what proportions of the available supply to use.

While the method seems to be more adaptable to surface mixtures where a definite per cent of bitumen is first decided upon, yet the general form could be extended to include concrete mixtures also.

It is of interest to note that the author is at present compiling a book on Materials of Construction which will be published in

the near future. There is an urgent demand for an up-to-date work on this subject, and the advent of Prof. Chatburn's book will be heartily welcomed.

Upon reading Prof. K. G. Smith's interesting account of the results of Engineering Extension one readily realizes how beneficial this work is proving to our industrial population. It shows in a concrete manner how eagerly the men and boys in the shops seek a broader knowledge, enabling them to advance another rung on the ladder of success.

Ames has easily proven herself capable of conducting the Engineering Extension and Two-Year Courses, at the same time maintaining the high grade technical courses. Not only has the high standard in collegiate work been kept intact, but the courses have been materially broadened. New courses in Highway Engineering and Structural Engineering, as applied to building design, that were created last fall, have proven quite popular. A complete course in Railway Engineering is soon to be offered with the opening of the transportation building. Steam and Gas Engineering have expanded into a fine new laboratory and with the completion of new Chemistry Hall, Chemical Engineering will be strengthened. In fact, the general growth of the four or five year courses has been quite gratifying during the past year.

However, Ames does not stand alone in this new field of service, for Wisconsin, the originator of this extension work, finds after thorough test, that engineering extension and technical courses travel side by side without friction, and with mutual benefit.

He is a familiar type—the fussy, fretful man who imagines that he is about the busiest man in town. He often dumps in the waste basket, unwrapped, copies of business or technical magazines that contain valuable articles, bearing directly on his problems. He fondly believes that he is too busy practicing to bother with what others are "preaching."

The trouble with this type of man is that he has not learned that the real executive is the man who so plans his work as to

leave a reasonable amount of time for reading and planning.

There are shoals and breakers ahead where the accumulation of new ideas ceases.

The man who declares he has no time to read is unconsciously advertising his small caliber, his slavery to detail, his arrested development.—*Printers Ink.*

College Notes

The transportation building has been completed, and is being equipped as rapidly as possible. The automobile testing apparatus will be installed at once, and an Alden brake and dynamometer for testing locomotives will be put in as soon as the appropriation for it becomes available. It will be capable of handling the largest Mallet engine, and will register a tractive effort of 125,000 lbs. It has been decided that for purposes of administration a new department will be created to take charge of the building and its equipment.

Mr. R. B. Dale of the engineering extension department gave an interesting talk to the engineering society on Feb. 26. His

subject was "Modern Methods of Printing and Engraving." He took up the history of the art of engraving, and described all of the modern methods, illustrating his talk with pictures. He had a very interesting exhibit of different kinds of cuts, half-tones, copper plates, three-color work, etc. He has delivered the same lecture in several of the towns over the state.

The Engineers were out en masse on Saint Patrick's day to celebrate the birthday of their patron saint, and the anniversary of the founding of Engineering at Iowa State College. There were no classes after nine o'clock, the Co-Engineers and Ags forming an enthusiastic audience, while all the Engineers took part in the parade.

The firing of the big brass cannon near Engineering Hall started off the celebration. The parade first drew up before the front steps of Central, where Donald S. Barry, senior engineer, gave an appropriate opening address. Following this, H. Noel, impersonating St. Patrick, was resurrected from a coffin, and assisted Barry in directing the ceremonies. The parade, consisting of over seven hundred engineers, passed in review before the good Saint. According to custom the Juniors were presented with their engineering shirts.

After a short talk by President Pearson, the parade, led by the college band, visited Ag. Hall and Margaret Hall, and then journeyed down town.

Parley Sheldon, mayor of Ames, in his effective style, congratulated the Engineers on their exhibition, and generously donated a car to take the girls back to the college.

The afternoon was a general holiday.

Throughout the whole affair the Engineers showed that old enthusiasm that has been dormant for a while, and acquitted themselves in a most approbate manner.

The Buckeye Traction Ditcher Co., of Ohio, has had a ditcher at work on the sheep pasture east of the college. For demonstration purposes they have agreed to dig the trenches for several hundred feet of drains, if the college will furnish the tile.

Professor Spinney spent part of the last month in Philadelphia, where he was a member of the committee appointed to test the coinage of the United States mint. The committee was composed of prominent chemists and physicists from all over the country. They weighed the coins very accurately, and tested them for fineness by the electrolytic method.

Prof. T. R. Agg attended the meeting of the National Conference on Concrete Roads in Chicago last month. He served as a member on one of the committees. The reports of these committees are given in the Engineering News of Feb. 26. They contain much valuable matter in regard to the present status of concrete road making.

Professor Stoek, of the University of Illinois, gave a series of three talks on anthracite coal to the students, on March 6 and 7.

A report on concrete road material has just been submitted by Prof. S. W. Byers and H. F. Wright. The report was made for the state geological survey, and will be issued in a bulletin by the highway commission.

The extension department has had a request from the independent telephone companies of the state for a course of instruction in the installation and operation of telephone systems. This shows that the people of the state are beginning to realize the purpose and the value of the work in engineering extension

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We are now making a special club rate of one dollar per year for the Iowa Engineer and the Road-Maker, which is a monthly journal published at Des Moines, and devoted to practical problems of highway engineering. This is an exceptional opportunity, of which every loyal engineer should avail himself.

Alumni Notes

Frank N. Field, C. E. '79, is with the superintendent of the Iowa District of the C., B. & Q. Ry. at Burlington, Iowa.

L. F. McCoy, C. E. '85, is Division Engineer on construction for the Canadian Northern Railway, near Sudbury, Ontario.

E. C. Dickenson, M. E. '94, is proprietor of the Algona Auto and Machinery Co. at Algona, Iowa.

Capt. Charles Lincoln, C. E. '94, is now an instructor in the War College at Washington, D. C. He is the only man with the rank of captain who has ever been assigned to such work.

A. E. Mellinger, M. E. '95, who has been in the employ of the Automatic Electric Co. for a good many years has spent the past three years in England. He is a director of the company and acts in the capacity of consulting engineer.

E. C. Macy, C. E. '96, was on the campus last month after an absence of three years. He is still with the Stone & Webster Construction Co.

Gordon F. Dodge, M. E. '98, has left Boston, where he was with the Stone & Webster Construction Co., and is now located in New York City. He has charge of all engineering work for the Robins Conveying Belt Co.

W. J. Devine, E. E. '98, is with the Chicago Northwestern Railway as general air brake instructor.

Dave Lingo, E. E. ex-'00, is interested in the Smith-Perry Electric Co., of Dallas, Texas. He has charge of the Telephone Specialty Co. He makes his home at Dallas.

Frank M. Weakley, Min. E. '02, is contracting for building construction, specializing on work under the Supervising Architect of the Treasury. At present he is at Dublin, Ga., working on a postoffice building.

O. L. Brown, C. E. '04, is in the Engineering Department of the Great Northern Railway Company at Whitefish, Mont.

H. T. Borsheim, M. E. '04, who has been with the Hart-Parr Co., of Charles City, Iowa, for several years, spent a few days on the campus last month.

Glen H. Corlette, M. E. '04, is engineer for Fairbanks, Morse & Company at Buenos Aires, Argentine Republic.

C. L. Creelman, C. E. ex-'05, is an engineer and contractor

at Tacoma, Wash. Mr. Creelman is an associate member of the Am. Society of Civil Engineers.

F. F. Jorgenson, Min. E. '05, is at present the chief engineer and superintendent of the Superior Coal Co., of Gillispie, Ill. He is also the chief engineer of the Consolidated Coal Co. at Buxton, Iowa. The output of the Illinois mine is between three and four million tons, while that of the Iowa mine is slightly over one million tons per year. John L. Clarkson, Min. E. '12, and J. R. Grier, Min. E. '12, are associated with Mr. Jorgenson.

R. W. Atkinson, E. E. '06, is with the Standard Underground Cable Co., at Perth Amboy, N. Y.

H. J. Gould, C. E. '06, is at Cincinnati, Ohio, designing and estimating in the office of the Feno Concrete Construction Co.

W. A. Marsden, E. E. '06, is a salesman for the Pacific States Electric Co., with headquarters at Seattle, Wash.

A. M. Weise, E. E. '06, is district traffic chief of the Minneapolis District of the Northwestern Telephone Exchange. He is living at 3351 North Fremont Ave., Minneapolis.

W. H. Knox, M. E. '06, is a consulting engineer in concrete construction at Marcus, Iowa.

Edgar W. Stanton, Jr., C. E. '07, is running a large ranch near Live Oak, Cal.

John Large, C. E. '07, is with the construction department of the Des Moines Bridge and Iron Company at Des Moines.

W. A. Danielson, E. E. '07, recently resigned his office as quartermaster in the U. S. army at Ft. Worden, Wash., to accept a very responsible position as electrical and assistant general manager of the Olympic Power Co., with headquarters at Seattle, Wash.

Walter E. Buell, C. E. '08, is with Ward and Weighton, contractors at Sioux City, Iowa.

John F. Rightmire C. E. '09, is with the El Paso and Southwestern Ry. at Tucumman, New Mexico.

Oscar G. Boden, C. E. '10, is at Mitchell, Nebr., where he is with the U. S. Reclamation Service.

H. E. Adams, C. E. '10, familiarly known as "Mike" visited the campus last month. He is with the A. G. & P. Co. on the dredge "Catt" at Galveston, Texas.

H. E. Schmidt, M. E. '13, is a superintendent at the C. A. Dunham Vacuum Heating Co., of Marshalltown, Iowa.

THE IOWA ENGINEER

CONTENTS

PUBLISHED MONTHLY DURING THE

COLLEGE YEAR BY

STUDENTS OF THE DIVISION OF ENGINEERING

IOWA STATE COLLEGE, AMES, IOWA

Annual subsription $1.00 Single Copies, 15 cents

Business Success

IN my more than thirty-five years experience in running manufacturing plants, practically alone, but employing sometimes in the vicinity of a thousand men, and almost always one or more engineers, the characteristic that has brought men to the front and enabled them to get away with good positions, and frequently make a great success for themselves or for me, has always been a keenness to do or accomplish the thing desired. They might not, and probably did not, see their way through when the proposition came to them, but they did not argue that it was impractical or that it could not be done. They "grabbed off" the opportunity to do something difficult and usually brought in a possible solution.

They were ready to assume responsibility and sought keenly to "make good" in any enterprise in which they took responsibility. People who do not seek responsibility, and then, with might and main, seek to "make good" at every opportunity, do not often get on.

In the early days, I enjoyed the acquaintance of certain Iowa pigs. When they are fat, their eyes are so located that they can see only ahead of them. With a desire to see what you are doing, they always face you and therefore turn tail to gate or bars through which you wish to drive them. It makes them proverbially awkward animals to deal with. They oppose you and try to go past you, going in the wrong direction. The pig-headed person in business does not get on. It is the person who is looking out in the direction in which you want to go and who is keen to see and find a chance to help you in that direction who is sure to succeed.

I have known but one pig-headed person to reform and become useful. That man was a scholarly man in the employ of a learned association with which I was connected, and who had been in that position for many years. The institution had gotten into a rut—had become fossilized. We were trying to put some life into it, but this gentleman would spend more energy, acuteness and intellect in showing us that anything we proposed to do was impractical and impossible than it would have taken to do the thing. Eventually we cut his salary in two and told him that we left him a livelihood until he should get another position, which he could more easily secure while he was yet employed. After struggling for a time to find a place, with our best efforts to assist him, but without success, he "saw the light," turned to and was so helpful and valuable to us in the things we had in hand that we had to restore his salary, and we became afraid some other association would get him away from us. And the work is now a source of great pride and pleasure to him. However, it is best to be headed right always, rather than to have to turn to and reform.

—L. W. Noyes

VOL. XIV. APRIL, 1914 NO. 7.

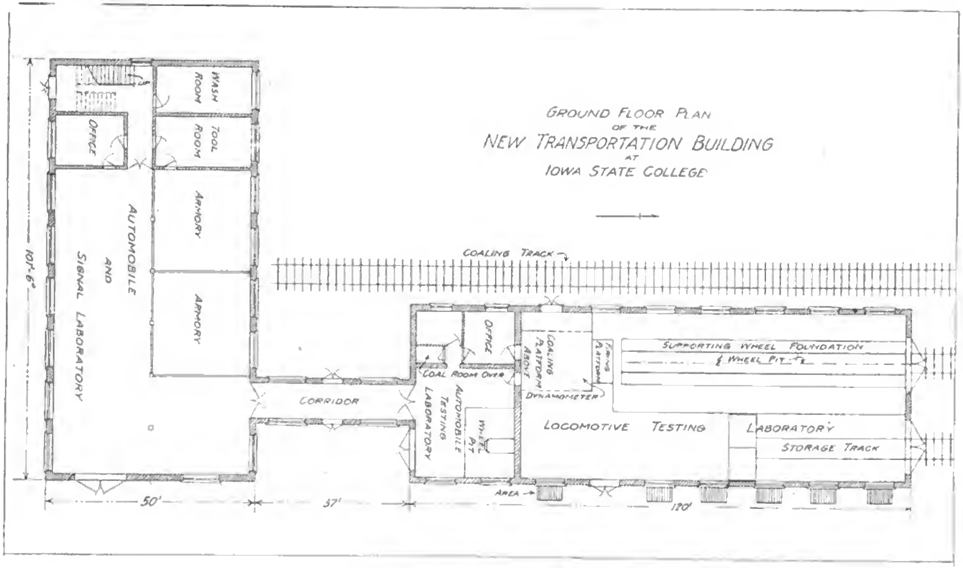
The New Transportation Building

E. E. KING*

At its last session, the State Legislature of Iowa set aside the sum of $65,000 to be used for a new Transportation Building at Iowa State College. The plans for this building were drawn up by Proudfoot, Bird & Rawson, architects, under the general specifications prepared by Dean Marston. The contract was let to Arthur H. Newman & Co., general contractors, Des Moines. They begun work in July, 1913, and finished in February, 1914. The building stands just west of and parallel to the Engineering Annex. It consists of two wings, one 50 feet by 100½ feet used for recitation and laboratory purposes, and one 43 feet by 120 feet for laboratory and experimental purposes. The structure is practically fireproof throughout. The walls are built of brick and the floors of hollow tile and concrete. The window sash are steel and allow a much larger percentage of lighting area than is usually found in this type of building.

The recitation wing is constructed on the monitor plan and is three stories high. On the first floor is a large laboratory to be used for automobile and signal instruction, a combination office and tool room, a wash and locker room, and two temporary

*Professor of Railway Engineering, Iowa State College


GROUND FLOOR PLAN
OF THE
NEW TRANSPORTATION BUILDING
AT
IOWA STATE COLLEGE
WASH ROOM
TOOL ROOM
OFFICE
ARMORY
ARMORY
AUTOMOBILE AND SIGNAL LABORATORY
101'-6"
50'
37'
120'
CORRIDOR
COALING TRACK
OFFICE
COAL ROOM OVER
AUTOMOBILE TESTING LABORATORY
WHEEL PIT
AREA
COALING PLATFORM ABOVE
DYNAMOMETER
FIRING PLATFORM
SUPPORTING WHEEL FOUNDATION
℄ WHEEL PIT ℄
LOCOMOTIVE TESTING LABORATORY
STORAGE TRACK

Interior view of Locomotive Testing Laboratory showing pit for support wheels, dynomometer and coaling platforms. The ample lighting area will be noted

tending the full width of the locomotive laboratory. This will be a three movement crane and will be used to handle the supporting equipment when making adjustments for different sized locomotives. For the present it is proposed to install just a simple smoke jack and carry the smoke and gases through the roof making no provision whatever for collecting the cinders.

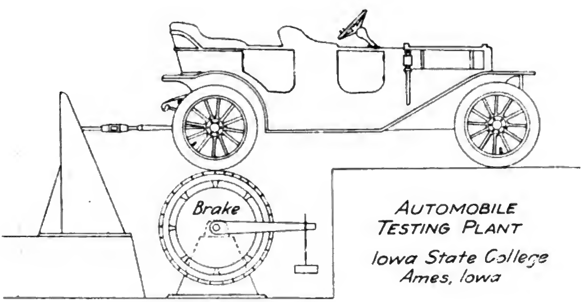
The College now possesses two locomotives. Both of these will be stored in this laboratory but only one of them can be used for testing. The older of these is a 36 inch gauge machine, the first one to cross the State of Iowa. It was owned by the Burlington Railway and was given to the College by that company. The other is an American type of locomotive and was donated by the Chicago & North Western Railway. After proper overhauling, this engine can in all probability be used for running locomotive tests.

This plant will be used for instructional work in graduate and undergraduate courses and for experimental purposes in connection with the Engineering Experiment Station. Its serv-

ices will be available to any road that cares to take advantage of the opportunities it offers. Several roads in the State have expressed their willingness to loan the College authorities such locomotives as they may be able to give up from time to time and to co-operate with them in making these tests wherever mutual benefits can be obtained.

The automobile testing plant will be constructed to operate the largest automobiles now built. The mechanism will be very simple consisting of two wooden rim wheels 48 inches in diameter and 15 inch face mounted in a pit so the top of the wheels will come just level with the main floor of the building. These wheels will carry the rear wheels of the automobile. The load will be applied by means of a brake attached to one end of the support wheel shaft. This brake will be used also for determining the horse-power delivered at the rim of the wheel. In addition there will be a lever dynamometer placed in the rear of the machine to register the draw-bar pull.

In all probability the equipment will be installed ready for operation by the end of the present semester. To a certain extent the plant may be used for commercial testing but its primary object will be for instructional work in connection with the Automobile Engineering courses and for investigational purposes under the direction of the Engineering Experiment Station.



AUTOMOBILE TESTING PLANT

Iowa State College
Ames, Iowa

Notes on California Highway Construction

E. B. RHINE*

On the 23d of July, 1912, the California Highway Commission awarded its first contract for highway construction under the $18,000,000 bond issue. This contract called for the rebuilding of 5.4 miles of the classic El Camino Real of the padras, lying between South San Francisco and Burlingame in San Mateo county. Mission street, leading out of San Francisco to the southward, connects this beautiful highway which, in turn passes into the Mission Road and the Monterey Road farther down the peninsula.

Contract No. 1 is a portion of Route 2 of the state highway system, traversing the scenic coast line from San Francisco to San Diego via Los Angeles. This highway being the only road directly connecting the suburban towns of Burlingame, Hillsborough, San Matea, Redwood City, Palo Alto, and San Jose, with the Exposition City, and also the main traveled route for all traffic up and down the peninsula region it is readily seen that it must be built to carry a fairly heavy city street traffic. It is estimated that about 75 per cent of this traffic is made up of motor vehicles, while the remainder is divided among delivery and grocery wagons, light buggies and an occasional four horse truck with a 3-ton load. No regular commercial teaming is done on this road, but motor trucks and vans up to 5 tons capacity are frequent.

The old roadway, composed of water-bound macadam, about 12 feet wide and 6 to 12 inches deep, had become badly raveled and deep holes were frequent. On account of the excessive crown acquired from successive metaling there was a fairly uniform cut made on the center line while the shoulders were approximately at grade and only required shaping and rolling. In a few places the cut at the side was 3 or 4 feet deep.

In the design of the pavement it was necessary, for the sake of economy and the lack of available funds, to select a type which would meet traffic conditions and yet be inexpensive. The improved roadway is 40 feet wide. The paved portion is composed of a 1 inch layer of sheet asphalt on a 5 inch base of 1:3:6

Portland cement concrete with an asphaltic paint binder. The pavement is 24 feet wide with a crown of 4 inches on 1.4 miles and 3 inches on the remainder, while earth shoulders 8 feet wide with a slope of 1¼ inches per foot carry the drainage to the gutter and afford ample room for all traffic in opposite direction.

The maximum gradient is 4 per cent for a distance of 300 or 400 feet in a few places only, and all changes in grade are joined by parabolic curves from 100 to 400 feet in length. Circular

View of completed California State Highway near Millbrae

curves of 420 to 5,730 feet radius connect all tangents having a central angle of 3° or more.

The contractor began operations early in August, 1912, but, on account of repeated delays due to financial difficulties and inefficient management, he made little progress. Late in November, when the contract should have been practically completed, he had poured about 6,000 feet of concrete base and the sub-grade was prepared with the stone and sand distributed on it, about 1,500 feet ahead of the mixer. The contractor was no

longer able to finance the work, and upon the order of the Commission, the bonding company, as surety for the contractor, took over the contract and placed it in the hands of a second contracting firm. Although this firm prosecuted the work with a well organized force of experienced men, the contract was not completed until late in June, 1913.

Under the second firm most of the loosening was done with a railroad plow pulled by whatever horses were necessary up to 18 horses. A ten-ton traction engine to which was attached an Austin scarifier was used at first as a part of the left over equipment, but the frequent turning around with the engine and the inability of keeping the scarifier squarely in the ground caused such loss of time that this method was soon abandoned. Practically all of the excavation was made with four horse fresnos; wheel scrapers being used on hauls of 300 ft. or more, and also dump-wagons on some of the long hauls.

After the trench was excavated approximately to grade, a gang of laborers with picks and shovels dressed it down to conform to its final crown, making proper allowance for settlement under rolling. As a rule, the old macadam roadbed was broken to several inches below subgrade, and after being properly shaped, was thoroughly watered and rolled with a 12 ton roller. In places where the cut was very shallow for some distance, it was found advisable to dress down the old surface to the true grade with picks, thus utilizing the rocklike foundation, almost as hard and impervious as the concrete itself.

The trench for the concrete base was lined with 2x6 inch planks laid with square butt joints and held true to line and grade by stakes 1x2x18 inches, driven down to about 1/4 inch below the tops of the headerboards so that a template would ride freely on their upper edges.

Sand and gravel were hauled and dumped on the subgrade in separate rows, properly distributed, according to the amount required per linear foot. The subgrade was found to be so compact that the hauling on it without planks, and the subsequent shoveling of materials caused no appreciable amount of earth to be incorporated in the aggregate.

Niles gravel, washed and screened to sizes from 1/4 inch to

2½ inches, was used on most of the work. Crushed limestone was also used, but was found to be more difficult to finish. The surface of the concrete was only shovel finished, and the finishing or spreading gang behind the mixer could be reduced by one man when using the gravel. Local "Baden" sand, a fine, but sharp, river sand, containing considerable clay and vegetable matter, was principally used. Great care was necessary to secure an acceptable quality of this sand, but on account of its accessibility and its proximity to the work, it was permitted in place of the "Ocean Shore" sand, a very coarse, sharp sand. "Golden Gate" and "Standard" brand cements were used.

Pouring concrete base on California State Highway near Milbrae

Two No. 6 Foote Batch traction mixers were used. One which had been purchased new by the first contractor, was driven by a 12 H. P. Fairbanks Morse gasoline engine; the other, by a 9 H. P. Standard marine type gasoline engine. The former had abundant power so that one operator could hoist the hopper and move the mixer ahead simultaneously without any loss of time, while the other had only power to move itself when the hopper was up or was released from the clutch. It was noted that the concrete flowed more readily and remained more uniformly mixed on delivery from a semicircular chute

than from the flat variety. To partially remedy the slow delivery from the flat one without thinning the mixture too much, the mixer was run on 3 inch planks cut in 5 ft. lengths for easy handling, three being provided for each side, and picked up and placed ahead regularly by one laborer who ran errands and did odd jobs meanwhile. The water supply was taken from a 44 inch main of the Spring Valley Water Co. through ¾ inch metered connections and carried in 1½ inch pipes in both directions. The maximum length of pipe from any metered connection was approximately 2,000 ft. Insufficient pressure was obtained, however, and it is believed that nothing smaller than 2 inch pipe should be used.

A complete and very efficient mixer crew was composed of eight laborers shoveling sand and gravel into, and wheeling, six wheelbarrows, one laborer putting in the cement and giving the hoisting signal, six laborers behind the mixer spreading and finishing the concrete, one laborer for errands and odd jobs, a gas engineer and a foreman. The aggregate was measured in wheelbarrows of 3 cu. ft. capacity, so that one barrow of sand, two of gravel, or stone, and one sack of cement made up the batch. In these proportions it was found that, allowing 10 cu. ft. per linear foot of pavement, there were from 6.7 to 7.5 cu. ft. of concrete in place per cu. ft. of cement used. This variation was principally due to the slight variations of the subgrade, from the 5 inch depth required. On the most uniformly prepared subgrade, the average was about 6.9 cu. ft. It was necessary to pour the concrete rather wet on account of the loss of water into the subgrade and to facilitate its movement to place. Although the subgrade was kept thoroughly sprinkled just behind the mixer, it was not desirable to fully soak the ground on account of the men's feet cutting it up so badly. After the concrete had taken its initial set, a steel broom was drawn lightly over the surface to remove the slight film or laitance.

The sheet asphalt surface was composed of sand, limestone dust and asphaltic cement. The sand was made up of a mixture of "Baden Commercial," a very fine sand, "Ocean Shore," a very coarse sand, and "Antioch," a standard asphalt sand, in

this region, so proportioned that an almost perfect standard mixture was obtained. It was necessary, however, to vary the proportions almost daily and to keep a close watch on the way it raked and rolled out on the road to maintain a fine, close-grained surface. The 1 inch layer cooled much more rapidly on the concrete than the thicker layers of 1½ inches or 2 inches usually laid on hot binder. For this reason it was necessary to send it out from the plant as hot as permissible under the specifications, 325° F., and follow the hot hand rollers with a 5 ton roller just as soon as could be done without the surface picking up. The intermediate size of roller, 2½ tons, was not used after the first day. It is believed that an 8 ton roller could be used to better advantage on this surface on account of the greater compression and the increased length of time of effective rolling possible. Greater density is secured, even with the 5 ton roller, than in the thicker surfaces with correspondingly heavier rollers.

The sand, limestone dust and asphaltic cement were carefully weighed at the plant; the dust and asphaltic cement on scales being on opposite sides of the mixing box, while the sand was weighed in a bottom dump hopper suspended from the platform of a specially hung scale attached to the sand storage bin. Enough temperatures were taken by the inspector to obtain an average for each load before leaving the plant and this was repeated by the engineer as soon as the load was dumped for spreading.

The binder used is an asphaltic paint so applied that the concrete is given a very thin coat of glossy black appearance. It is composed of one part by volume of asphaltic cement, of the consistency used in the surface, to two parts by volume of engine distillate. The asphaltic cement is heated in a small portable kettle to a temperature not to exceed 325° F. and a measured quantity ladled into a 10 gallon mixing pail. When this has cooled to a temperature of 250° F. the engine distillate is added slowly, to prevent foaming, and stirred vigorously for about one minute when it becomes a uniform mixture. The concrete surface having been thoroughly cleaned and swept, the liquid is poured on with buckets and swept lightly in a small

wave for a short distance. After a few minutes the sweepers go back and sweep the surface clear of all excess paint in the depressions and retouch portions that may for any reason require more. This condition is indicated by a brown surface. An excess of distillate will produce the same appearance, but it will be uniform over the entire surface. The proportion of asphaltic cement to distillate will vary according to the density, or porosity, of the concrete surface, a lean mixture requiring less distillate than a rich one. It is essential that the paint penetrate the concrete to insure a perfect bond. Any earth or vegetable matter in the surface of the concrete will prevent a bond, while, if the concrete is perceptibly damp, the paint will lie in a thin film on the surface and may be scraped off with the foot. If water falls on this binder before it has thoroughly dried, that is, before the distillate has evaporated and the cement hardened, the water gets underneath and floats the film free from the concrete. The concrete dries out much more slowly under the paint film and, it is believed by the writer, that the paint, once floated by moisture, never becomes as strong a binder as before. The distillate is gone and it merely dries, or hardens on the surface of the concrete as any bit of spilled asphaltic cement will do. It is, therefore, inadvisable to carry the painting farther ahead of the surfacing at night than what will be covered in the first two hours' work on the following day. Two men can mix and spread the binder on 12,000 square feet of surface per 8 hour day. In fair weather the fresh binder should in no way interfere with the asphaltic surfacing if kept two hours ahead, for by that time it is dry and hard and will not stick to the tires of motor trucks or wagons. Any excess paint left in depressions, such as heel marks, becomes apparent on rolling the hot surface by showing a grease spot and in extreme cases by a bubbling up of the liquid through the surface layer. With ordinary care no such trouble is experienced.

On removing portions of the asphalt surface it is found to be uniformly bonded to the concrete. When picking it loose, or trimming back a joint, irregular chips of concrete are usually pulled up and these often show fracture through one or more pebbles.

It is noted that the 1 inch surface on the asphaltic paint

binder moves or welts very little under the roller as compared with that laid directly on the dry concrete.

In the specifications for this highway contract the asphaltic paint binder was not included, but was ordered as extra work under a special work order. On the stretch of 5.1 miles on which this binder was used and on which the proportions varied somewhat, it required .077 gallons of engine distillate and .315 pounds of asphaltic cement per square yard of surface covered. The total cost of the asphaltic paint binder, including 15 per cent on labor, was $0.016 per square yard. It is apparent from this that the asphaltic paint binder costing a trifle over 1½ cent per square yard, is a cheap binder as compared with the old type used on city streets at 27 cents to 36 cents per square yard. Although its economy is yet to be proven, it has thus far given every assurance of being well adapted to this type of construction.

Hardening Steel with Compressed Air

A process whereby steel is hardened by means of compressed air is now in use by a German firm in cases where only certain parts of the metal require hardening. The customary methods of hardening by chilling the steel in water, oil, or special baths is not satisfactory in such cases, owing to the tension created between the hardened and unhardened portions of the treated metal. In the new procedure the compressed air is sprayed over the metal through specially designed nozzles, by means of which, by varying the number and spacing of the openings, the degree of hardening may be accurately graded. The claim is made that a wide range of results can be obtained by adapting the shape of the nozzle to that of the work.—*Journal of Industrial and Engineering Chemistry.*

Certainly, there are other things, other characteristics, that will be the determining factors later, but for your immediate future nothing is more important than neatness. Neatness is evidence of carefulness, and carefulness of accuracy.—*Howard.*

Cost Keeping in Relation to Public Work

J. H. AMES*

Within the past few years there has been a popular and justifiable demand for a much closer check on the expenditures of our public funds. This demand has placed upon the engineering profession the duty of keeping an accurate cost record on all public work under their supervision. It is unnecessary in this article to point out the needless expenditure of our public funds or the waste that has occurred through ignorance, incompetence or petty graft in the administration of these funds, but rather to suggest cost keeping as a means of providing a clear record of all expenditures.

One of the most important duties of an engineer associated with public work is to see that all of the money spent under his direction or supervision is spent judiciously, and that a record is kept of that expenditure, so that it may be accounted for at any time in the future. It is often the case with an engineer looking after public works that he is called upon to direct or supervise a large number of jobs over an extensive area. In order for him to be able to give a close cost estimate of such work it is necessary to keep a rather detailed cost account. Such a cost keeping account would serve several purposes; the two most important of which are to provide a final record of the cost of any individual piece of work and to provide a means of cost reduction during construction or on work of a similar character.

That a clear record should be kept of the cost of each individual piece of work is very important from the standpoint of a business policy. No public record is complete that does not show the actual cost of each separate part of the work, as well as to whom the money is paid. Public service corporations have been foremost in installing complete cost keeping systems and these systems have proven beyond a doubt their value. It remains for the engineers associated with public works to adapt as efficient systems as are now in use by these corporations.

*Office Engineer, Iowa Highway Commission, Ames, Iowa

Public accounting demands that all expenditures should be in itemized form, and a cost record should be no exception to this rule. This does not require that an intricate or cumbersome system should be adopted, but rather one that is simple and complete and can be operated at a low cost. There is always a desire on the part of someone to cast unjust suspicion upon a person in responsible charge of the expenditures of any public fund. The engineer, who is often the person against whom such charges are directed, should be able to fully protect himself against any such unjust criticism by providing a complete cost record of each individual piece of work under his direction. A clear, concise statement of the cost as a public work will be a great factor in the promotion of confidence in that engineer's ability.

If it becomes generally known among the workmen that a complete cost record is being kept, they immediately develop the incentive to do better and more efficient work. They feel that their work is being watched and appreciated, and will give more efficient service under a direction of this kind than in a place where individual interest is not appreciated. A rivalry will soon appear among the foremen on labor crews which will stimulate the interest among the men and add materially to the efficiency of the organization.

If an efficient cost keeping method is used, it will furnish the engineer with comparative costs on each individual piece of work, as well as furnishing the foreman with cost data on each laborer under his direction. The undesirable labor may be then disposed of and labor saving devices or other labor substituted.

Considerable net saving in cost will be found after an installation of such a system in the small tool and repair charges. More care will be taken by the men in regard to the loss of tools, etc., where a record is kept of these small charges.

An accurate cost record of each different kind of work enables the work of a similar nature to be estimated with a greater degree of accuracy in the future. This is one of the most important functions of cost keeping and is applicable to public as well as private work. It is a well established fact that most engineers make their greatest blunders in economics. This is probably

true to a greater extent in public than in private work and a large number of these blunders may be traced directly to the lack of cost data.

Where there is a considerable amount of public work contracted for, the necessity for some cost record becomes apparent in the regulation of the judgment of the engineer in awarding contracts. Local conditions will nearly always govern the price bids on any particular kind of work and for that reason it is essential that the engineer have some accurate cost data that he can apply in judging the reasonableness of the prices which he receives.

Moreover, there is quite often the necessity for the adjustment of extras, the cost of which will be a subject of dispute and will be determined very largely from the evidence that can be shown as to the actual cost of such work under similar local conditions.

The providing of a means of cost reduction of work under construction is one of the most important considerations in keeping cost data. An accurate cost system will always enable the engineer in charge to analyze the cost of the work as it progresses. Such an analysis will often show where labor saving devices or changes in the method of performing certain parts of the work will effect a great saving in cost. There is also a further chance of showing the efficiency of machines or methods by a cost record so kept. A cost record accurately kept should point out the value in dollars and cents of the importance of the specifications and the design itself. A poor design or faulty specifications can be readily determined by a study of the data obtained from their use.

It has not been attempted in this article to take up the requirements for a cost keeping system, as it is a subject which requires a great deal of individual study for each kind of work and one upon which volumes have been written. The prime object of the article is to point out in a brief way a few of the necessities of keeping actual cost records as a business policy and in cost reduction of public work.

If we could see ahead as well as we can see behind, most of us would take the back track at once.

The Soldier Valley Drainage Project

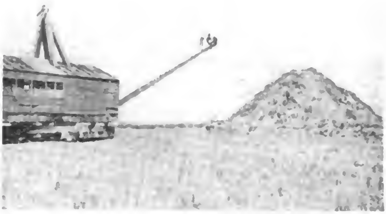
S. A. McGAVREN

From \$50.00 per acre to \$150.00 per acre in four years is the phenomenal jump in price made by about twenty thousand acres of land in the Soldier Valley Drainage District. This district is located in Harrison County, Iowa, about midway between Sioux City and Council Bluffs. It comprises thirty-three thousand acres of land, or the equivalent of two hundred one-hundred-and-sixty-acre farms.

Of this land six thousand acres was originally swamp land, perennially overflowed, and not worth the taxes assessed against it. This land has increased in four years to a value of \$100.00 to \$150.00 per acre. Eighteen thousand acres was low land, subject to overflow, although it could be farmed to some extent. This has increased in value from fifty to sixty per cent. The rest of the land in the district has increased about twenty per cent in value.

The district lies in the valley of the Soldier River, a small stream which, for about eight miles near the mouth, has reached the flood plain stage. The banks of the river have been built up by constant overflowing, and sediment has deposited in the bed of the stream until it is actually higher than the land on either side. The channel was crooked and shallow and the flood plain was a series of disconnected swamps and ponds. Six or eight times each season, following heavy rains farther up the valley, the stream would rise over its banks, and overflow the country for four miles on each side. Some of the land produced a crop not oftener than one year in six or seven, and some was never known to yield a crop.

The method of attacking the problem, as prepared by the chief engineer, was to dig a large channel, intercepting the Soldier at the point where it leaves the hills, and running straight west to the Missouri River. This channel was to run across comparatively high ground, most of which was good farm land, and would shorten the length of the stream about nine miles. This is the plan that was finally adopted. The main channel was designed with a forty foot bottom, and side slopes 1:1, with



View showing Dredge and Extent of Waste Pile

an average cut of about nine feet. It was largely through gumbo soil, although some sand was encountered, and some loam. The contract price was six and two thirds cents per yard. The work was done with a two yard drag line dredge, operated by a 50 H. P. kerosene engine. When the ditch was half completed the dredge was destroyed by fire, and had to be replaced.

Having provided a channel with sufficient capacity to carry away all the flood waters of the Soldier, it yet remained to provide for the drainage of the swamps and ponds in the old flood plain. To do this a system of five lateral ditches was designed, all of them open ditches and all emptying into the old channel of the Soldier. As these ditches had to handle the run-off from a comparatively small area, the old channel was sufficiently large to serve as an outlet. The laterals were six and eight feet in bottom width, and most of the work was done with a one yard dipper dredge.

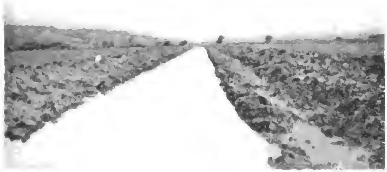
An interesting phenomenon occurred at the point where the main channel taps the Soldier River. The river at this point is nine feet deep, and the ditch is eighteen feet deep. This caused the ground water in the vicinity to be lowered several feet. For a distance of seven hundred feet the waste banks and the berms settled from three to six feet, causing the bottom of the ditch to rise about six feet. The ground was apparently compact, and its action was apparently due to the fact that the subsidence of the ground water had opened up new pores in the soil.

The cost of the ditch was divided among all of the property in the district, according to the benefit received. A board of

Scene on East

Soldier River

Ditch 1912



appraisers, consisting of an engineer and two property owners, was appointed by the board of supervisors. These men, after looking over the ground, classified all of the land as dry, low, wet or swamp, and it was assessed accordingly. None of the land had to pay over $10.00 per acre, and some of it less than $1.00.

The work was started in the spring of 1912, and should be finished by the first of August, 1914, requiring two years and four months for its completion.

J. S. Wattles, of Missouri Valley, is Engineer-in-Chief of the work, and W. A. Price, of Omaha, Nebr., is the engineer in charge of construction.

The manager of a large company in the Middle West told me recently that in filling positions with college graduates he always gave preference to those who had been prominent in students' activities. "It does not matter," said he, "whether the man distinguished himself in athletics, in politics, or in literary activity. It simply means that he is a man of strong will and initiative, a man who can be relied upon to achieve results, without an external pressure."—*Karapetoff.*

The practical man thinks quantitatively and qualitatively, while the impractical man thinks qualitatively only.—*Kerr.*

Rejuvenating A Gas Engine

J. G. VREELAND

The power of a hundred and sixty men was required to loosen the pistons of the gas engine recently installed in the new Mechanical Laboratory at Iowa State College.

The engine of the Fairbanks-Morse make was used for testing purposes at the college three years ago. When the old laboratory was abandoned the engine was dismantled and placed in an old shed nearby.

The frame of the engine was set on its foundation in December and the work of assembling begun. The cylinder heads which are bolted to the cylinder with one and one-quarter inch bolts required two days work of two men to remove them, due to the difficulty of getting hold of the castings, and the excessive rusting. The intake valves in the heads presented some difficulties because of inadequate tools with which to remove and replace the valve springs. The fly-wheels were cast with a split hub and after removing the rust from both the shaft and the inside of hub with emery cloth, these were thoroughly lubricated. The wheels were then rolled to place on planks raising them to the proper height, and were then worked on by turning with the aid of two bars in the rims, two men on each bar. It was found necessary to set a screw-jack against the hub of one to force it in place. The pistons did not move under this severe strain, so jacks were placed under bars in the wheels to loosen them after they had been soaked in kerosene over night. These jacks developed the power of 160 men. They were then turned to the lowest position and the cylinders polished with very fine emery cloth and kerosene. Some difficulty was experienced in removing the exhaust valves due to the rusting of the seats and guides through which they were driven. They were then placed in a lathe and polished, and the seats refaced with a file to remove the excessive pitting. When put in place, they were ground with a paste made of emery and hard-oil. It took five hours to grind them to a seat.

In rebuilding the engine, arrangements were made to take indicator readings and gas samples which would be as reliable

as possible. The cylinders have been tapped in the sides into the clearance chamber through the water jacket. This was done by drilling and tapping through the outer and inner wall of the cylinder and placing therein a brass screw nipple with a plug in the outer end. This plug can be removed and the indicator connected. In the gas manifold leading from the mixer to the cylinder was placed a quarter inch pipe which was threaded four and a quarter inches allowing it to extend past the center of the manifold opening. The pipe was drilled with twenty three-thirty-second holes and capped on the outside of manifold.

It may astonish you to find out how kindly each member of the Faculty feels toward you. Each member is a friend and an older brother. You will have every consideration as men; you will be treated with justice always, patience generally, and malice never. You must reciprocate and be kindly and considerate, just in your judgments always, vindictive and revengeful never. Sometimes you will not view things as your instructor does. In such cases you must be open-minded enough to feel that when your judgment conflicts with that of your instructor, the chances are that the older man is right and that the younger man is wrong. This is not always so. Age does not make men infallible. When you feel certain you are right, discuss your case good temperedly and fairly with your instructor, showing him the respect that is paid a judge in a court of law. You always have the right of appeal to the Dean of the College.—*Shenchon.*

To attain the highest success as an engineer you must not be the type of man who knows how to do things excellently but cannot tell others how to do them,—the man who gets knowledge abundantly but can apply it only through his own fingers. Instead of devoting your energy simply to increasing your own output by fifty or even one hundred per cent, it is far better,—you make yourself more useful to the world—by using your energy to increase the output of each of one hundred men by ten per cent. The world recognizes this by awarding the prizes to the administrators.—*Hayford.*

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EDITORIALS

In This Issue

One of the greatest additions to the engineering equipment of Iowa State College is made this year by the new transportation building. Professor E. E. King, in charge of Railway Engineering, gives a description of the building in this issue. The provisions for locomotive and automobile testing will fill a large demand for commercial testing, besides being used for instructional purposes. The laboratory for testing road building materials will be one of the best equipped in the west. The scope of our Engineering Experiment Station work will be greatly widened by these new facilities. The acquisition of this build-

ing and its equipment will do much toward ranking Iowa State College still higher among the engineering schools of the country.

— I. E. —

In a foreword Mr. L. W. Noyes, B. S. '72, gives us the creed of a successful manufacturer; being proprietor of the Aermotor Company of Chicago.

Although a graduate in Agriculture and having gained experience on an Iowa farm, Mr. Noyes' career has been that of a manufacturer, due to his mechanical turn of mind and exceptional inventive genius. Having to his credit many useful inventions, and especially the windmill tower of light but rigid angle iron construction, and being the pioneer maker of steel towers for high tension transmission lines.

He has had many opportunities of holding offices of high honor and trust, but has refused to allow his name to go before the public, preferring to give his time to his chosen work.

— I. E. —

We take pleasure, also, in calling attention to the article on highway construction in California by Mr. E. B. Rhine, B. C. E. '09. Permanent highway construction is now a live question before Iowa people, and in choosing different types of construction it will pay to learn of the success or failure of different road building or pavement materials even in outside states. The demands of a permanent road, economical in cost, are much the same in California as in Iowa. So the experience cited by Mr. Rhine may be considered in practical application, as well as being a matter of general interest. The construction work is described in detail and will be of much interest to highway engineers.

— I. E. —

Mr. J. H. Ames, office engineer for the Iowa Highway Commission, gives us, in a clear-cut way, the fundamental reasons in his article on "Cost Keeping in Relation to Public Work." In county offices especially, the new highway law is causing some radical changes in the accounting of public expenditures. Systematic cost keeping is required. As is pointed out, this is very important from an engineering standpoint. A record of the

cost of each individual piece of work should be kept so that future estimates can be made intelligently. Engineers on all public work will be required more and more in the future to study the most efficient system of cost keeping.

—— I. E. ——

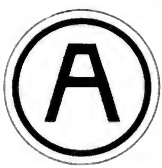
Mr. S. A. McGavren, B. C. E. '15, gives us an interesting description of a drainage project in Harrison County, Iowa. The two notable features of this project are its comparatively low cost and the enormous rise in value of the land benefited. The highest assessment was not over ten dollars per acre, and some of the land increased in value "from fifty dollars per acre to one hundred and fifty dollars per acre."

Such articles as these, dealing with important Iowa engineering problems, are always welcomed by the Iowa Engineer. We would be glad to receive more of such articles from students or engineers practicing in Iowa.

Ames Engineers Adopt Recognition Pin

A movement that started in a recent meeting of Tau Beta Pi, has resulted in the engineers adopting a standard recognition pin. There has been keenly felt the need for some manner of insignia to designate Ames engineers after leaving college.

The pin, as adopted, is a quarter of an inch in diameter, with a cardinal colored enamel "A" in the center, having a background of gold, and surrounded by a cardinal circle. The "A" is after the pattern of the regular athletic letter. The pin may be worn by junior and senior engineers, all graduates of the engineering division, as well as any who have attended school and are now engaged in engineering practice.



The Ames Engineers' Recognition Pin

This movement is symbolical of the "Ames Spirit" that is

always alive and aggressive, and which is truly indicative of the effectiveness and success of the school.

A certain indescribable thrill and pride is experienced on the meeting of two "grads" after graduation, who, though they be total strangers, feel something in common. Such meetings should not be infrequent with a means of identification now provided for our engineers. As an alumnus of an eastern university recently remarked, "In my years of travel I've no doubt seen many graduates of my alma mater, but have met few. Why isn't some means of recognition provided?" After all, one of the great benefits of a college course is the friendships formed. Why not facilitate the continuance of the process during the succeeding years?

The Effectiveness of Manual Training

Manual training in public schools has made giant strides in a decade. From the most modest of beginnings it has grown till now scarcely a school board in the country fails to make this a most important part of its educational planning.

In some towns and cities it has become almost the dominant feature of school work. In one eastern school for example, the boys of the manual training school repair the school buildings for pay, conduct a co-operative farm school for profit, and are planning to build a gymnasium for their school in the same businesslike way they have learned to do other things for themselves and for the community.

The average boy of today likes to be creating something tangible. He wants something besides book knowledge. He wants to be able to do useful things with his hands, so that he will be able to go from school with a definite means of earning a living. It ought to be the aim of the common school to give every boy and girl in the land the means of earning a livelihood.

On entering college the boy should receive credit in the proper laboratory work for his manual training experience, just as much so as for his other high school studies. This would avoid the overlapping of college and high school work, and so enable the broadening of the college course.

College Notes

On March 18, when the excitement incident to the celebration of St. Patrick's birthday had subsided to a certain extent, the senior and junior civils left for Chicago, bent on their annual inspection trip. There were twenty-seven students, and Professor Kirkham, assisted by Professors King and Agg, chaperoned the bunch. On the morning of the nineteenth Professor King superintended a tour through the C. & N. W. terminal, and also showed them some work on track elevation in the yards. The same day the bunch took in the Railway Show. The next day the plant of the Illinois Steel Company was visited, and the party saw the Bessemer converters, the plate and structural steel mills, the blast furnaces, and the power plant. On the following day the plant of the American Bridge Co., at Ambridge, Ind., was visited.

On March 22, Professor Agg, who was on his way to a Good Roads Convention, met the bunch and took them on an inspection trip of the different types of paving in the city. They were accompanied by the assistant city engineer, who was very courteous to the party, and gave them some interesting information.

The following day the plant at Gary, Ind., was visited, and the manufacture of the steel from the ore to the finished product was witnessed. The same day the plant of the American Bridge Co., at Ambridge, was again revisited, and that night the bunch took in the Universal Cement Co.'s plant at Buffington, Ind. On the twenty-fourth the party spent the morning in visiting the city testing laboratory, and inspected some more pavement. The party broke up at noon of that day.

At the regular meeting of the C. E. Society on April 9, Professor King gave an illustrated lecture on the subject "What I saw in Mexico." He had a large collection of slides showing the scenery and the life of Mexico. His talk was based upon the experiences encountered during the time that he was employed by the National Railways of Mexico, and was enjoyed by a large audience.

On the eleventh of April the Engineers were hosts at their second annual ball. It was a closed night for college functions, so the dance was very well attended. It is estimated that over two hundred engineers were there. The gymnasium was decorated in the college colors, cardinal and gold. The programs, in true Engineering style, were lettered by hand and printed on blue-print paper. As a response to the general demand of the students, the ban on the modern dances was removed, and everyone tangoed to his heart's delight. Dean and Mrs. Marston, and Professors Kirkham, King, Paine and Gabriel, with their wives, chaperoned.

Prof. K. G. Smith, of the Engineering Extension Department, recently delivered a lecture to the prisoners in the penitentiary at Fort Madison. This is the first lecture of a course that is being prepared for these men. So far as is known, this is the first attempt on the part of a state to provide extension work for its prisoners.

A new college song, entitled "That Dear Old School at Ames," written by "Dad" Fleischman, has recently made its appearance, and is proving very popular.

The highway commission is conducting a series of experiments on reinforced concrete beams of different designs. They are making use of a Riehle Testing Machine for breaking the beams. This machine has been out of commission for several years but has just been overhauled and set up in the hydraulics lab. It has a capacity of 100,000 lbs.

Alumni Notes

M. J. Riggs, C. E. '83, is manager of the plant of the American Bridge Company at Toledo, Ohio.

E. J. Nichols, C. E. '84, who is engaged in railroad construction work, now has a locating party of sixteen at Randolph, Texas. His home is at Tyler, Texas.

Hiram S. Stewart, C. E. '86, is an architect at Kerrobert, Sask., Canada.

Walter F. Trotter, M. E. '92, is a mechanical engineer at Cincinnati, Ohio.

John E. Banks, C. E. '89, is with the American Bridge Co., at Ambridge, Penn.

Harry E. Hunter, ex '98, is an architect at Cedar Rapids, Iowa. After leaving Ames, Mr. Hunter went to the University of Illinois where he finished the course in Architecture in 1901.

R. K. Morse, ex '00, is western manager for the Pawling and Harnishfeger company, manufacturers of lifting cranes, at Portland, Oregon.

J. W. Brehl, M. E. '03, is now located at Rockford, Ill., where he is engaged in engineering work.

R. S. Goulden, M. E. '06, is teaching mechanical drawing at the West Des Moines High School.

L. Wayne Wilson, M. E. '06, is with the C., B. & Q. Ry. at West Burlington, Iowa.

Theodore T. Meyling, M. E. '07, is a U. S. inspector at Keokuk, Iowa.

G. M. Wills, E. E. '08, visited on the campus last month. He is located at Goldfield, Nev., as district manager of the Nevada-California Power Co.

R. M. Hopkins, M. E. ex '08, is a teacher in the Cushman Trade School at Tacoma, Wash.

V. V. Eby, C. E. '09, is with the Barnett McQueen Company at Ft. William, Ontario, Canada.

Fred B. Johnson, E. E. '10, is in the Commonwealth Edison Company's Testing Department, at Chicago, Ill.

D. M. Cooley, C. E. '10, is with the Fairbanks Morse Co., at St. Louis, Mo.

E. D. Prouty, C. E. '10, is in the implement department of Sears Roebuck Co., at Dallas, Texas, one of the largest institutions in the state.

John Hyland, C. E. '10, county engineer of Clarke county, was on the campus last month. His headquarters are at Osceola.

A. D. Givson, E. E. '11, is with the Light and Power Company at Boone, Iowa.

Vern Madsen, M. E. '11, is with the Curtis Brothers and Co., at Clinton, Iowa, where he has charge of maintenance and power.

Roy Howes, M. E. '11, who was formerly with the People's Gas and Coke Co., at Chicago, is now located at Fayetteville, Arkansas.

W. D. Cameron, E. E. '11, who is with the General Electric Co., at Schenectady, N. Y., spent about seven months last year in the coal fields of the D. W. & W. at Scranton, Pa.

F. E. Boden, C. E. '12, is located at present at Frontdale, Oregon, where he is engaged in Highway Engineering.

C. H. Myers, M. E. '12, is with the Tri City Railway and Light Company at Davenport, Iowa.

Eugene DuVal, M. E. '12, is now with the Mitchell, Lewis Motor Company, at Racine, Wis.

E. R. Thornburg, E. E. '13, who has been with the Northwestern Telephone Co., at Willmar, Minn., since graduation, is now located at Grimes, Iowa, where he is manager of the Farm Mutual Telephone Company.

Olaf N. Gjellefold, C. E. '12, besides being engaged in general engineering work at Forest City, Iowa, is now county engineer of Winnebago county.

A. L. Campbell, M. E. '12, who was formerly at Moline, has been at his home in Park Rapids, Minn., since July 13th, on account of poor health.

F. E. Triggs, M. E. '13, is in the heating and plumbing business at Clarion, Iowa.

C. E. Crowley, C. E. '13, is resident engineer on the viaduct that is being constructed at Eldora, Iowa.

Lyle A. Butler, Min. E. '13, is engaged in mill work for the Utah Copper Co., at Garfield, Utah.

"A WORK OF AN ALUMNUS"

Wisconsin Capital Dome, W. J. Thomas, B. C. E. '95 Superintendent of Construction Chief Engineer. Dr. Geo. P. Post and Sons, Architects, New York City.

THE IOWA ENGINEER

CONTENTS

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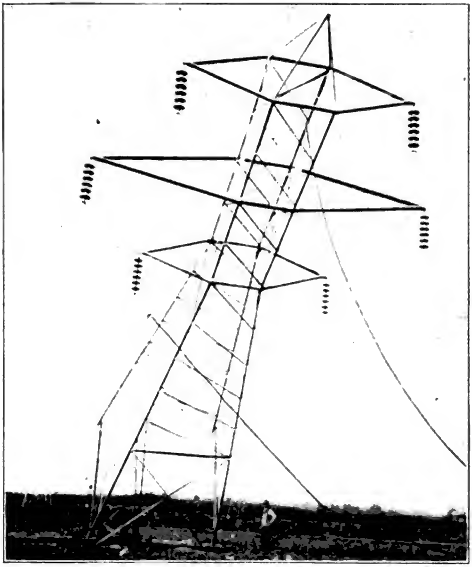
Long Distance Transmission

The Southern Sierras Power Company's High Tension Transmission Line

R. H. HALPENNY

The transmission of electrical energy has reached a state of development such that a transmission line of two hundred odd miles in length is no longer a cause for wonder or comment. The engineering profession, since the building of the first lines of considerable length, is not particularly interested in new long distance lines, except where they show marked departures from standard practice or introduce some startling innovation in design, and the public is not given to expressing any symptoms of concern so long as the supply of energy for domestic purposes is uninterrupted; just so long as Mr. Consumer has the use of light, heat and power by the turning of a switch, he is not likely to worry about the source of supply.

Notwithstanding the fact that the above would indicate a general feeling of indifference toward a transmission line, it may not be amiss to call attention to a few points concerning the design, construction and operation of one of the longest transmission lines in the country. The recent supplementary sheet compiled by Mr. Selby Haar for the Electrical World



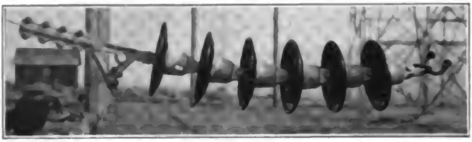
Raising completely assembled tower

CONDUCTORS.

Seven strand aluminum steel cable is used as the line conductor, the center strand being of steel with a high tensile strength. The combined cross sectional area of the cable is 24,600 C. M., leaving aluminum equal in cross section to 4-0 cable. The steel core is in itself able to take the entire strain of the cable at worst condition of ice load and wind, although the cable is so strung that at normal temperatures the aluminum shares the strain with the steel.

INSULATORS AND HARDWARE.

Six units of Locke Suspension insulators is the standard insulator for both suspension and strain purposes. The standard



St·ndard Insulator and dead end clamp, showing also U bolt and twist link used for fastening to tower ends

Locke suspension clamp, with a slight modification, was used for fastening the conductors to the insulator, an aluminum sleeve about 10″ long being placed on the conductors at the clamp for protection from the arc in case of a flash over the insulator.

For properly holding the conductor at points of deadening, it was necessary to design a special clamp to develop both the strength of aluminum and steel. A clamp in itself would not suffice, since the center strand of steel would slip. This was taken care of by providing a casting of malleable steel with both a clamp for holding the entire conductor and a boss around which the center strand of steel was wrapped and fastened. At dead ends short jumpers lead around the arm and insulators and all joints between jumpers and line cable are made by the use of aluminum clamps having a double groove for clamping the two ends that are joined.

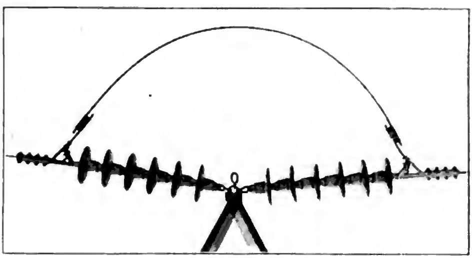
SPLICING.

The problem of making a good joint in the line conductor is most important and because of the bi-metallic character of the cable it was essential that the joint should make a mechanically strong connection of the steel and at the same time give a joint of good electrical characteristics, so far as the aluminum was concerned. The final solution was the use of a two part sleeve of aluminum. After the steel center is joined by the use of a McIntyre sleeve of steel, the two parts of the aluminum sleeve are screwed together and clamped over the conductor at the ends. The clamping of the aluminum is done by means of a portable hydraulic jack, by which it is possible to exert many tons pressure on the ends of the sleeve, this pressure causing

the aluminum to "flow" into a perfect union, giving a joint that is very efficient indeed. Where it is necessary to make emergency repairs in the field, special parallel groove clamps are used until such time as the outfit for making the permanent splice can be provided, the hydraulic jack, because of its weight, not being part of a patrolman's outfit.

TOWER FOOTINGS.

In the construction of a line that traverses 240 miles of cultivated land, mountainous country and desert, it is to be expected that the character of the footing for the towers would vary greatly. The standard stubs used on this line are 3"x3"x¼" angle, 6'-6" long, with a 12"x2'-0" channel at the bottom, the channel having the web slotted for the insertion of the angle and being held in place by tapered pins through the angle. These stubs, on test, showed a holding power of from 16,000 pounds to 20,000 pounds when properly tamped in good dry, sandy soil, and, in fact, would often break out at the bolt holes before they could be pulled out of the earth. These values would be very misleading if they were to be used without qualifying them to suit the changing conditions of soil in 240 miles of Western country. From a solid rock formation, almost all kinds of soil conditions were encountered. In one locality the soil resembled volcanic ash and had absolutely no holding power. In such places it was necessary to resort to concreting, placing enough concrete around the stub to give anchorage due to the added weight and increased surface re-



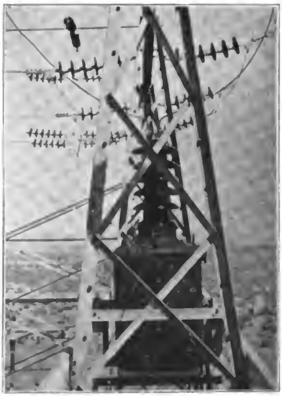
Standard dead end and jumper

sulting from the mushroom shape of the concrete footing.

At some points in alkaline soil, subject to moisture, the galvanizing was found to be insufficient protection from corrosion, and in such places the stubs have been concreted to a point above the ground and the upper part of the stub given a coat of asphaltum paint as well.

VOLTAGE CONTROL.

With constant voltage impressed on the generating station end of the line (this being made necessary because of other transmission lines radiating from the center of control), the



140,000 volt current transformer. Cut in line at station

voltage variation from no load to full load at the receiving end of a long high voltage line is very marked and it is important that attention be given to the regulation of the receiving end voltage. During normal operation this is taken care of by the operation of the turbo sets of the San Bernardino Station as synchronous condensers, the voltage being held constant at this station by a Tirril regulator. At times it is not possible to use this method, as, for instance, when the steam plant is disconnected from the tower line and switching operations are being

carried on. At such times the voltage at the receiving end is held down by the use of air core inductance coils, that are shunted across the line on the low tension side of the receiving transformers. This is a unique as well as effective method of counteracting the condenser action of the line and has proven sufficient to keep the voltage down to about normal value at the receiving end.

SWITCHING.

One of the special features of the line is the use of air break switches for such high voltage and severe service. At the ends of the two circuits, Bowie three phase, double break, horn type, 140,000 volt switches are installed on forty-five foot towers, the set at the San Bernardino end being electrically operated from the switchboard of the steam plant and those at the Northern end of the line pneumatically operated. Bowie switches are also installed at intermediate points along the line for cutting the circuits into sections for tests or repairs.

CONCLUSION.

In this brief article it has not been attempted to describe in detail the many features of a transmission line that deserve mention, nor is it possible to dwell on the stations, which, by the way, are all of the out-door type. The description of the lines and stations, with their equipment and auxiliaries would require much more space than it is possible to devote to it. The writer has merely mentioned the more important features that might prove of interest to one not familiar with long distance transmission and tower line construction and operation.

Now I want to state in the most emphatic terms at command that, no matter how high the standard of your school, when you graduate your education is only well begun, that if you do not continue your studies with more vigor than you have commonly employed, you will have exceedingly small chance to win fame or position. You will be left standing at the post, and the races will be won by men who know their deficiencies and who take prompt and energetic steps to remove them.—*Harrington.*

Some Fundemental Engineering Features in the Drainage of Arid Soils

R. A. HART.*

When the fact that drainage is an important factor in the reclamation of arid lands is brought to the attention of the average man, it occasions a great deal of surprise. Nevertheless, the fact remains that a considerable portion of lands that have been brought under irrigation must subsequently be drained, and at the present time not less than 2,000,000 acres of formerly productive land are unfit for cultivation and will remain so until properly drained. Such lands are to be found in every western state and in practically every valley where irrigation is a factor in the agricultural development. Even some of the newest projects have been confronted by the problem and it knows no bounds of slope, location, soil, sub-soil, or topography. Lands requiring drainage are to be found on high gravelly benches or plateaus as well as in river bottoms; on steep hillsides as well as on flats, and on sandy and gravelly soils as well as on so-called "heavy" soils. They are to be found in the Lower Rio Grande Valley in Texas, at an elevation of less than 75 feet, and on the upper reaches of the Rio Grande, in Colorado, at an elevation of 7,500 feet. They are as much at home in valleys as in the Great Basin or down by the sea.

NATURE OF LANDS NEEDING DRAINING.

Lands so injured are recognizable in several ways. Sometimes true swamps are formed, in which tules, cat-tails, sedges and water grasses abound. In some instances, the swamps are saline so that no vegetation can exist. More often the land is merely water-logged and the ground surface is merely moist and may be walked over safely, except in certain boggy spots. In still other instances, the ground surface is entirely dry and is coated with an accumulation of alkaline salts which abound in arid soils owing to the lack of sufficient precipitation to leach them out. Their presence on the ground surface is due to the

*Supervising Drainage Engineer U. S. Dept. of Agriculture.

fact that at some season of the year the ground water-table has risen to within a few feet of the surface. Alkaline salts in the soil are concentrated near the upper limit of saturation, which is always some little distance above the free water-table, owing to the capillary attraction of the soil spaces. When the ground water-table stands within a few feet of the surface, the salts are concentrated at the surface and evaporation of the water leaves the salts deposited on the surface in a crystalline or powdered form. Then, unless the water-table is reduced and sufficient water falls to leach out the salts, they will remain there indefinitely, prohibiting the growth of any but the most alkaline resistant plants, and being blown about in great white clouds by the wind. Often the salts are deposited in such quantities as to render the growth of any plant impossible, in which case the land becomes entirely barren.

CAUSE OF THE CONDITIONS.

These conditions are brought about by irrigation. Nature has given arid soils certain drainage capacities, sufficient for the meager precipitations they receive, but vastly insufficient for the great quantities of water put upon them by irrigation. When such lands are first put under cultivation the ground water-table is generally found many feet below the ground surface, but after a few years of irrigation, the water-table rises to or near the surface. The source of the water is downward percolating water from the irrigation of the injured tract itself and from other lands; lateral seepage from the irrigation of higher lands; waste water; and seepage from ditches, laterals, canals and reservoirs.

It is usually necessary to drain lands upon which the annual rainfall is in excess of 48 inches yet in many arid sections from 4 to 25 feet of water is applied by irrigation in addition to the natural precipitation. The percolation of one foot of water below the surface will fill up several feet of soil, so it is easy to understand why the ground water-table rises so rapidly.

DRAINAGE THE CURE FOR THE DIFFICULTY.

The injurious condition of these lands has been brought about by artificial means and artificial means must be resorted to to correct the difficulty. It is evident that drainage is the

cure of the swamp and water-logged lands. It is just as true, but not so evident, that drainage is the cure of the alkaline crusted areas. By drainage the water-table is lowered to such a distance that capillary attraction can no longer bring the alkaline salts to the surface, and the drains serve as outlets for the water that must be used to leach out the salts already in the surface soil. Alkaline areas must be heavily flooded and the salt laden water must pass down through the soil in order to effect a reclamation.

Drainage as applied to arid soils, however, is not the same as that applied in the Middle West or the swamp areas of the South. True, open drainage canals and covered tile drains are employed but there the similitude ends. The problems of design and construction are totally different and new methods and machines have had to be applied.

FACTORS OF DESIGN.

Some of the most important factors entering into the problem are: source of the damaging water; geological construction of the soil; presence of alkaline salts; depth of root zone of plants in arid regions; physical nature of the soil and sub-soil; topography; crops; duty of water used in irrigation; distance to gravity outlet; cost of power for pumping; cost of tile; cost of labor; evaporation, and, sometimes, precipitation.

This last factor, of prime importance in humid sections, is generally ignored in the arid section. If the source of the damaging water is in the irrigation of the tract itself, the total quantity of water applied and the percentage percolating downward must be determined in order to provide sufficient capacity for the excess. If the water makes its way to the tract by lateral seepage from adjacent or higher lands or from canals and reservoirs, the drains must intercept it before it reaches the tract and if the water enters the tract vertically, owing to an upward pressure, it must be cut off by suitable devices and carried away by drains.

DEPTH OF DRAINS.

One of the most important features of arid drainage practice is to secure the proper depth. In this item the great difference between arid and humid drainage is shown most clearly. Plants

in the arid section are unusually deep-rooted and a greater root zone must be provided. Furthermore the alkaline salts must be kept down from the surface. It has already been pointed out that the salts tend to concentrate several feet above the free water level, owing to the action of capillary attraction. It is evident, therefore, that a drain having a depth equal to or less than the capillary height would be useless as the salts would be concentrated at the ground surface to work such injury as they might. Experience shows that drains having a depth of 3 feet are worthless. The minimum effective depth is usually about 5 feet. Six feet is still better, and many drains in the arid section are being laid to a depth of 8 feet or more.

Aside from these considerations, the required depth is influenced by the location of any more or less pervious stratum. Obviously it would be a mistake to lay a drain at a depth of 5 feet if the soil were underlain by a gravel or sand stratum at a depth of 5½ to 6 feet. On the other hand it would not be good economy to lay a drain 8 feet deep in a pervious soil having a clay sub-soil after the first 5 feet. It is good practice to have the drain cut through the pervious stratum so that the tile may bed on the more impervious stratum. In most cases, a drain will not be effective unless it is so laid.

LOCATION OF DRAINS.

Equally important is the matter of location of drains. In the humid section it is difficult to locate a tile line that will not do *some* good, but in the arid section, it is quite possible to install a first class drainage system that will be absolutely ineffective. It is necessary to get the water before it has an opportunity to do damage. This usually means to intercept the water before it reaches the tract. In some instances, drains may be laid in the natural depressions which will result in a general lowering of the ground water-table and the expedition of the natural movement of water toward those localities. More often, however, the drains must be laid diagonally across the slope and above the injured area. The most frequent location is at the foot of benches or terraces, or at the change in slope from a steep to a lighter grade. Lands injured by lateral seepage very often occupy a belt in such a location, the damaging water being

forced to the surface because of a reduction in its velocity owing to the change in slope. A single line of drain located at this critical line may effect the drainage of the entire belt of wet land and it is thus possible to make a single line of tile take care of a whole tier of 40-acre tracts. If the slope is quite flat and fairly uniform, however, several lines may be required.

USE OF RELIEF WELLS.

When the damaging water moves through a deep stratum and reaches such a change of slope the water is forced to the surface vertically, or nearly so. Manifestly, there are both economical and practical limits to the depth of drains, so in such a case drains are laid at moderate depths and relief wells are bored, along the line of the drain, to the deep pervious stratum, and are connected up to the tile line. The water, being under pressure, rises up in the relief wells and flows out of the drains. Such relief wells find many other applications and are an important feature in arid drainage practice.

FREQUENCY OF DRAINS.

From the foregoing it will be quite evident that the oft repeated question, "How far apart should drains be placed in the arid section?", must go unanswered. The best answer given so far was that of a Colorado drainage engineer who replied that the drain lines should be installed about a year apart. Thus the effect of one might be noted before another was installed. It may be said in general that lines are effective over much greater distances than in humid lands, the distance between lines ranging from 300 feet to a half-mile.

REQUIRED CAPACITY.

The most difficult problem confronting the drainage engineer is the determination of the required capacity. The source of water is easily determined but its rate of movement is hard to measure. If the damaging water comes from the irrigation of the tract itself, it is customary to provide a drainage capacity of from one-fifth to one-half the irrigation supply, the coefficient depending upon the nature of the soil; the kind of crops raised; the amount of evaporation and the amount and method of applying the irrigation water. If the damaging water comes from external sources it is necessary to determine the amount of

water used on the contributing area and the percentage of this that will reach the injured tract. Often the drainage discharge is many times the amount of water used on the tract itself.

If the ground water-table varies in height during the season, it is possible to estimate the required capacity very closely by observing the daily or weekly variation and ascertaining the percentage of void spaces in the soil. From these data the flow required to prevent a dangerous rise may be calculated.

If the soil is continually saturated, the required capacity may be ascertained by deciding upon the number of days in which it is desired to lower the water-table to a given depth; then determining the percentage of void spaces in the soil and the evaporation. If there is any surface run-off, this must also be added to the quantity of water that must be taken care of.

SUB-SURFACE INVESTIGATIONS.

The features touched upon show the absolute necessity of making careful and thorough studies of the underground conditions. This is done by means of test boring and pits. It is also necessary to make topographic surveys and studies of general conditions in the surrounding areas. The drainage of arid lands is a highly scientific proposition and demands the best efforts of engineers.

CONSTRUCTION OF OPEN CANALS.

Open drainage canals are used for main outlet systems and large laterals, but owing to the fluxible nature of the soils in the arid section and the high value of the lands, they should only be used when the cost of covered tile drains is exorbitant. They must have flat side slopes and be carefully designed as regards grade and alignment. It is often necessary to install drops to keep the velocity within bounds.

The use of ordinary floating dredges for the construction of open canals is out of the question owing to the size of the canals and the lack of a sufficient quantity of water to float the dredges. Drag-boats and walking dredges are equally useless. The machine that has had the greatest success is the drag-line excavator, operating on the surface of the ground and proceeding up the slope ahead of the work, which in the arid section must always begin at the outlet of any line. These machines are usually

operated on skids or small rollers. A few are provided with broad wheels running on a timber platform. In most cases, however, caterpillar traction should be provided.

The problem of maintenance of open canals in arid soils is very serious and no effort should be spared during construction to reduce maintenance to a minimum. Besides the trouble caused by silting and the spalling of canal banks, the growth of vegetation often complicates the matter, and in some sections tumble weeds are very troublesome.

CONSTRUCTION OF TILE DRAINS.

For trenching, hand labor is often employed, but where the job is large enough to warrant, trenching machines should be used. These must always be supplied with caterpillar traction. Both the wheel type and the endless chain type are employed but the application of the former is somewhat limited. In either type, a portable shield must often be drawn behind the machine, in order to support the banks until the tile may be laid and blinded.

When hand labor is employed, small crews must be used and the trench must be cut from surface to grade in short sections, as rapidly as possible, and the tile must be laid and blinded at once, or caving of the banks will make the work very difficult and expensive. This is due to the fact that arid soils are extremely fluxible when wet and in most cases there is no sod to help support the banks. If systematic, rapid trenching is not successful, then it will be necessary to use a tight sheeting to hold the fluxible material out of the trench until the tile can be properly laid.

ACCURACY REQUIRED.

Drain lines must be carefully laid out and must be installed true to line and grade, otherwise the drain will be inefficient, to say the least, and may become entirely obstructed by silt. As a rule tile are abutted as closely as possible and in quicksand the joints must be protected by means of a collar of burlap or cheese cloth.

MATERIALS.

Hard burned clay tile is the only really satisfactory material for drain conduits, although lumber box drains are used in many

places where the cost of clay tile or the freight rate is prohibitive. Whenever lumber box drains are employed, the boxes should be provided with bottoms. In the case of small boxes, having the planks running longitudinally, sufficient aperture for the entrance of water will be afforded, if short blocks made of lath are placed between the bottom and sides at intervals of 2 to 3 feet. In the case of larger boxes, planks are used for the sides and short cross-pieces are employed for the tops and bottoms. The top pieces are fitted close together but a space is left between the bottom pieces to provide for the entrance of water. The bottom and top pieces must be milled with a shoulder at each end, which will engage with the sides and prevent the collapse of the box when the nails are destroyed, which is often within a few months. The lumber itself, if kept wet continuously, will last for a long period of time.

Owing to the presence of alkaline sulphates in arid soils, cement tile is not trustworthy. Hand-made tile is soon destroyed and there is a suspicion against even the best grade of machine-made tile.

PROTECTIVE DEVICES.

There are a number of protective devices for use in the drainage of arid soils. Manholes have a rather general application. Their purpose is to afford an opportunity for observation of the action of the drain lines and for the operation of sewer rods in case the lines become clogged up with roots or mud. They also serve as sand-traps if they are extended a foot or so below the grade of the tile. They may be modified to serve as surface-inlets and flushing wells. If the soil is not particularly fluxible it is sometimes sufficient to substitute vertical stacks of tile which are connected to the tile lines and afford an opportunity for observation. Vertical stacks of tile may also be used for surface-inlets by protecting the mouth of the stack and they are also useful as flushing wells at the upper end of each branch. Irrigation water may be turned into these wells for flushing silt and sediment out of the lines.

The outlet of drains must be protected against the entrance of small animals and against erosion. Flumes must be provided for carrying streams of irrigation water across the tile lines.

In the case of open drains flumes, bridges, culverts and siphons

must be used and provision made for the entrance of storm and waste water from irrigation. The use of large quantities of water near open canals presents a problem not encountered in the humid section.

SUBSEQUENT TREATMENT.

In the subsequent treatment necessary, another difference in humid and arid drainage practice is shown. In any case the land must be cultivated especially well and in some instances humus and fertilizers must be introduced into the soil. This is particularly true concerning nitrogen. The best practice is to grow some leguminous crop that may be plowed under. Manure and straw are also plowed into the soil.

If the soil has been alkaline, still further treatment is necessary. The ground surface is generally crusted and sometimes puddled by the action of the salts and as a rule the rainfall is insufficient to leach out the salts into the under-drainage. It is necessary, therefore, to vigorously cultivate the ground surface and flood it with irrigation water. This usually calls for leveling of the ground surface and diking up the tract into parcels of such size that water may be ponded to a depth of from one to two feet on the surface. After a suitable application has been made and the salt laden water has percolated away, the ground surface must be stirred up to prevent evaporation from returning the salts to the surface. Then if an analysis shows that a dangerous amount of salts still remains, the leaching process must be repeated.

After the salt content has been sufficiently reduced, the land should be cropped as soon as possible. Shading crops should be grown in order to minimize the evaporation. The plants should be as alkaline resistant as possible. They should be profuse feeders and should provide a great deal of humus when plowed under. It has already been pointed out that the plants should be of the leguminous variety if the soil is deficient in nitrogen.

Irrigation should be by the flooding method, even if a change has to be made from the furrow method or from sub-irrigation. As large areas as possible should be covered at once and the covering should be as uniform as possible. Knolls and ridges should not be allowed to extend above the water level as the

salts will move toward any unsubmerged areas and will be concentrated there instead of being removed.

COSTS.

While unit costs of drainage in the arid section are high, the cost per acre is moderate, owing to the fact that so few lines are necessary. The cost of ordinary trenching ranges from four cents to twenty cents per foot. More difficult work ranges from 20 to 35 cents per foot, while trenching in fluxible material, requiring sheeting, may cost several dollars per foot. Drainage ordinarily costs from $10 to $25 per acre while more difficult work may run twice as high. The average will be between $15 and $20 per acre.

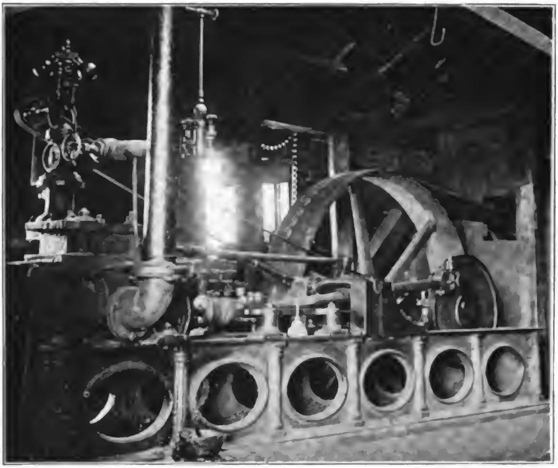
IMPORTANCE OF THE ALKALI PROBLEM.

In conclusion it may be well to give some idea as to the amount of salts that occurs in arid soils so that some idea of the importance of their bearing upon the problem may be had. Most arid soils contain some salts but when they represent less than 0.2% of the weight of the soil they receive little consideration. Some plants are injured when the percentage reaches 0.4% and when the percentage is higher than this the situation demands attention. There are large areas containing more than 3% and some areas run up to very much more than that. Speaking in terms of percentage is not so impressive, however, as a consideration of actual quantities. Assuming that the weight of a given soil is 100 pounds per cubic foot, 3% of salts would represent 3 pounds per cubic foot or 18 pounds in a 6-foot column, having a ground surface area of one square foot. This would amount to 392 tons per acre; 62,720 tons per 160-acre tract, or 250,900 tons per square mile. This enormous quantity of salts would load 5,000 large freight cars. Truly a drainage system in an arid soil has a Herculanean task to perform.

Integrity is absolutely essential to high professional success; for the engineer's position is frequently judicial, and he must bring to his work all of the spirit of fairness that is given to man.—*Harrington.*

An Old Timer

R. H. PORTER.*



"The Old Timer" Oldest Engine in use in State of Iowa

A fact that is not generally known but nevertheless true is that the oldest steam engine now in use in Central Iowa or perhaps in the state is owned and used by the Madrid Milling Co., of Madrid, Iowa.

This engine was hauled from Keokuk by wagon to a place a few miles north of Madrid in 1855 and was first used to run a saw mill. In 1868 the engine was brought to Madrid to run a grist and saw mill. When it came into the hands of the present owners it was used to run an up-to-date flouring mill. The old engine has been in constant use since its arrival in the state and has worn out four boilers. To see it running today you

*Associate Professor in Mech. Engineering, Iowa State College.

View showing connection of eccentric rod to rocker arm

would hardly realize that it has about sixty years of service to its credit.

As to its economy of steam the writer has nothing to say. There is no name plate or any mark by which one could tell where it was manufactured.

The photograph with a few words of explanation will give the reader some idea of its construction and the methods of design of early steam engines.

The bed is made of cast iron in four sections, bolted together at the corners. It is about twelve feet long and a foot and one-half wide. It is apparent that the designers of the early days looked to the artistic side much more than those of the present. The cylinder is 8"x22". The heads are bolted through a flange. There is no lagging of any kind to retain the heat in the cylinder. The valve chest containing the simple D valve is rather crude, being bolted to the top of the cylinder. The steel piston rod is 2" in diameter, connecting to a cast iron crosshead. The crosshead shoes are of hickory and have to be replaced about every two or three months. Originally the valve rod was one

solid piece but owing to the cutting of the packing they placed in it a knuckle joint.

One of the most interesting features of the engine is the attachment of the eccentric rod to the rocker arm. The connection is the same as that used on some of the early Corliss engines to connect the reach rod to the wrist plate, being only a slot in the arm. On the rocker arm is a large lever which can be seen in the photograph, marked "A." It is about 2" in diameter and 18" long. This was used as a method of working the water out of the cylinder before the drain cocks were put on.

The crank shaft is of cast iron, 5" in diameter and about 5' long. The cast iron fly wheel shows no evidence of being trued up in any way.

It is interesting to note the massive construction of the rocker arm and the blocks supporting the bearings of the same.

Figs. 1 and 2 show two cards taken from head and crank ends respectively of this engine as it was running in the summer of 1912. The indicator was attached to the cylinder through the drain cock openings and the peak in Fig. 2 was due to a slug of water coming into the indicator. The cards show 13 H. P. at 105 R. P. M. Further analysis of the cards I will leave to the reader.

The engine is throttle governed. The steam comes direct from a multi-tubular boiler in a 3" main. The exhaust is a 4" main. The governor and lubricator are of modern design as well as the grease cups. These trimmings are recent additions

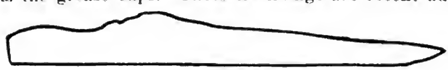


FIG 1 HEAD END

FIG 2 CRANK END

The Department of Structure Design---Its Ideals and Aims

ALLEN HOLMES KIMBALL, S. M.*

The course in Structure Design has been established in response to a demand for the improvement in the design of buildings adapted to conditions in Iowa. Instruction will be offered in the design of rural architecture as well as for engineering and architectural structures.

Not only will students in the Division of Engineering be given the opportunity of doing work in the department but all those in other departments who so desire may classify in elective courses. For example regular agricultural students can elect work in the design of farm structures, and women in the department of Home Economics the art of designing attractive homes.

A complete course extending over a period of four years has been carefully planned. Students classifying in the regular course will be eligible for the degree of Bachelor of Science in Structure Design. Graduates of this four year course can secure the advanced degree of Structure Designer in one of two ways, either upon the completion of five years of successful professional work and the presentation of a satisfactory thesis, or by taking one year of graduate work at the College, completing one year of satisfactory professional work and presenting an acceptable thesis.

The course is so planned as to give the student a good and thorough training in the art of design as applied to architectural structures and a sound basis for the application of engineering knowledge to the problem as presented by conditions in Iowa. The problem in the course in structure design is to adapt architectural expression to the local conditions. The obligation of the department is to train leaders in design. For leadership men must be given power to understand the movement in which they are to take part, a knowledge of fundamental elements and principles and their application to specific

*Professor of Structure Design, Iowa State College.

practical types of buildings. Such understanding demands familiarity not only with the history of structure design itself, but with general history, language and a multitude of other subjects for which the four year course affords but little scope. The course has been so arranged as to give as much cultural work as possible without reducing the purely professional work to a minimum.

Central in the work of the department will be the direct instruction in design. This will be given not only by the solution and criticism of problems in design, but by constant parallel lectures and research work in the library. The sequence of lectures and problems is an orderly one, devised to secure a steady development from simple to complex, with attention focussed on one new thing at a time.

In the first semester of the Freshman year a course of general lectures on the principles and qualities of Structure Design will be given, each lecture to be illustrated by the steropticon. These lectures will continue through four successive semesters. Parallel with them there will be library work and practice in the design and presentation of the elements in the draughting room. Every effort will be made to familiarize the student with as large a vocabulary of architectural terms as possible.

The third year will begin the purely professional training of the student. He will enter courses in working drawings and building construction and the design of various types of simple structures. As he gains profiiciency the problems will become more difficult and hence more interesting. The originality of the designer plays an important part in the work. In order to gain facility and ease in the use of the various media and kinds of expression the student will be trained in freehand drawing and water color rendering.

In the fourth or senior year the student will have the opportunity of studying the design of reinforced concrete structures, heating and ventilation, plumbing and sanitation, together with ample time for advanced problems in structure design, including an original thesis.

The staff realizes the need of a good library of architectural material in order to conduct the work. Provision is being made for a generous appropriation for books, lantern slides and other

equipment. With ample equipment there is only one thing else necessary and that is a strong, sturdy and enthusiastic enrollment of students. Success cannot help but follow and thus spread the good work of the College through the large and prosperous state of Iowa.

Highest and Largest Chimney

A chimney 506 feet high, the tallest in the world, has been built for the Boston and Montana smelters at Great Falls, Mont. Its nearest rival is 40 feet shorter and the next highest in America is 140 feet shorter. The main barrel of the chimney has an inside diameter of 50 feet at the top and about 65 feet at the base; its discharge capacity is 4,000,000 cubic feet of gas per minute. There are 17,000 tons of brick work in the entire structure, and the foundation, which is 103 feet across at the bottom and 22 feet 6 inches high, contains 4,300 cubic yards of concrete. An octagonal base, 78 feet 6 inches across at the bottom and 46 feet high, separates the main barrel from the foundation. A dust chamber, 478 feet long, 176 feet wide, and 21 feet high closely hung with small wires, strains the smoke before it enters the chimney. The flue which leads from the dust chamber to the chimney is 40 feet wide and 1,238 feet long. The whole chimney has an acid-proof lining.—*Popular Mechanics.*

An elementary but complete course in architecture, especially as it relates to engineering construction, should form a part of the curriculum; and special attention should be paid to aesthetics in designing.—*Waddell.*

The world's problems do not come systematically and in the preferred order of easy ones first, followed by a gradation of the most difficult. They come by chance and they hit you endwise, sideways, and with all degrees of percussion. You must meet them, solve them, get good out of them, and utilize them as the means to further achievement.—*Kerr.*

A Glimpse of Agricultural Engineering Building

Illuminating Power of Kerosene

WM. KUNERTH.*

While kerosene oil as an illuminant has been largely replaced in the last decade in our cities and towns, it is still used to a great extent in agricultural districts. When we consider that it is easily installed, that it is self contained, that it is portable, and that the light from a kerosene oil lamp is less detrimental to the eye sight than most any other illuminant, we can possibly see why it has stood in the forefront of illuminants for the last fifty years or from the time that oil was first refined. Nor is the kerosene lamp affected by anything that corresponds to irregularities in the workings of the power or gas plant.

There are a great many factors which affect the illuminating power of kerosene, and hence the latter is very hard to determine. By illuminating power is meant the candle-power-hours-per-gallon. As an approximation it may be stated that about 1000 candle power hours are obtained from a gallon of kerosene when burned under optimum conditions.

The accompanying table shows that at the price at which oils are sold at present much more has to be paid for the same flux of light if the more expensive oils are purchased.

Cost per gal.	Ave. Illum. Power	No. of Samples	Ave. Cost of 1000 C. P. Hrs.
10cts.	1114	5	9cts.
12cts.	1105	6	11cts.
13cts.	1115	6	12cts.
15cts.	1090	22	14cts.
18cts.	948	8	19cts.
20cts.	1019	8	20cts.

As shown in this table, the more expensive oils are the poorer bargain.

A great deal is said in favor of red oil. Experimental facts show that their illuminating power is only about 950 candle-power-hours-per-gallon. The average cost of red oils is 18.57 cents per gallon, and the cost of 1000 candle power hours is 20

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cents. It is therefore less economical to purchase red oil unless a person is willing to pay a high price for a little red alkanet root or aniline which is used to color the oil.

Whether or not an oil is a good illuminant can not be told when burning some in a lamp unless very accurate and careful photometric means are employed. But it is unnecessary to burn oil in a lamp to test its illuminating properties. Experiments have been carried on which show that there is a definite relation between the illuminating power of an oil and certain physical characteristics. A full treatment of these experiments can be found in a bulletin of the Engineering Experiment Station under the same title as this article.

It has been found that those oils which have a high illuminating power are also high in density, index of refraction, viscosity, and surface tension. Viscosity is more variable than any other factor. Knowing any one of these physical characteristics of an oil, its approximate illuminating power can be foretold. It is of interest to note here that oils from the east have a lesser density than oils from the western fields. Even the flash point and the burn point give us some idea of the illuminating power of an oil. The higher these are the more light a person can expect to get from a gallon of the oil. As is well known, all kerosene oils must be tested by our State Oil Inspectors. There are fourteen of them in this state, and a part of their work consists in determining the flash point of kerosene oils. This point as defined by the law of the state is the lowest temperature at which sufficient vapor is given off to produce a perceptible flash when a small flame is passed over the surface of the oil. Our state law sets 100 degrees F. as a minimum for the flash point. In recent years the demand for gasoline has been so great that there was little danger of finding the lighter and more volatile ingredients in kerosene. They have all been distilled off, thus leaving kerosene oil denser than formerly. The flashing test is a very important test as it is the inflammable vapor evolved that causes accidents. If an oil whose flash point is considerably below 100 degrees F. were used in a lamp, an explosion might occur, for it has been found that after several hours of burning the oil in a lamp basin acquires a temperature of 92 degrees F. or more, depending on

the temperature of the room and upon other conditions.

It is unfortunate that the kerosenes from a gallon of which most light is obtained produce more fogging of the chimney than do those which have a low illuminating power. Strange as it may seem, a kerosene exposed to light thereby depreciates in value as an illuminant. It seems that the oxygen dissolved in it is changed to ozone by sunlight and that this reduces the illuminating power. Perhaps every one has noticed that the light from a tungsten lamp is more nearly white than is that from a kerosene oil lamp. That there is a difference in the color of the flame produced by different samples of kerosene oil may not be so generally known. The flames from the lighter oils are more nearly white than those from the denser oils. The color also varies considerably with the height of the flame, being more nearly white when the flame is low. This seems due to the fact that when the flame is turned higher the carbon particles get only red hot, no longer white hot, and hence emit less light.

At the rate at which electric energy is sold at Ames (11.7 cts. per K. W. hr.) the cost of illumination with tungsten lamps is found to be approximately the same as when the same illumination is produced by kerosene lamps. With the kerosene illumination however, rooms are very seldom lighted to the same degree of brightness as they are with tungsten lamps.

The low brilliancy of the kerosene oil flame is in its favor. By this is meant that the candle power per unit aréa is small. This varies with the height of the flame and is found to be about six candle power per square inch when the flame is burning at its best. When the flame is lower the brilliancy is higher and vice versa. Moreover it varies with the density of the oil used, being less for a light oil than for a dense oil. For a candle the brilliancy is about 3 candle power per square inch. Almost all the modern illuminants have a very high brilliancy, as much as 1000 candle power per square inch for the tungsten filament. This is very injurious to the eyes and makes shades, globes and reflectors necessary. By these means the total flux of light can never be increased, only decreased; and the installation is less efficient because of them.

Being essentially a small illuminant, the kerosene oil lamp is

placed close to the object viewed. If the reader finds that he is inconvenienced by glare due to reflection from the paper, he can shift his position or that of the lamp slightly and thereby avoid the difficulty. If he finds that the illumination is too low or too intense, a slight change in the distance from the lamp to the paper he is reading will make considerable difference in the illumination on the paper. This is not the case when the source of light is far from the surface which is being illuminated, as is usual with electric lamps.

The true ultimate value of any position offered to a newly fledged engineer is an inverse function of the salary paid.—*Waddell.*

Form the habit of the card index and the document file. Make of your room your office, and have it a business office. More time is lost in hunting up mislaid letters, papers, and documents than you can imagine.—*Shenehon.*

In order, therefore, that the technical man, who in material things knows what to do and how to do it, may be able to get the thing done and to direct the doing of it, he must be an engineer of men and of capital as well as of materials and forces of nature. In other words he must cultivate human interests, human learning, human associations, and avail himself of every opportunity to further these personal and business relations.—*Johnson.*

Study well the English language and obtain a thorough command of it, in order that you may be able to speak and to write it with conciseness and vigor. Perfect yourself in style by reading well written books, even if they come under the denomination of light literature. A little of the latter affords relaxation, and, when really good, can do no harm to a professional man, unless he becomes so addicted to its perusal as to neglect more important reading.—*Waddell.*

Two Year Vocational Courses Revised

R. BURDETTE DALE*

Experience with the two year courses in engineering this year has indicated the necessity for revising them to comply more fully with the needs of the student. Accordingly, four specific courses will be offered next year in place of the general course which was available this year. The new courses are:

1. Course for Electrical Workers and Stationary Engineers.
2. Course for Mechanical Draftsmen and Mechanicians.
3. Course for Structural Draftsmen and Building Superintendents.
4. Course for Surveyors and Roadmakers.

The courses as outlined do not constitute a trade school. They are intended for ambitious young men of mature habits who wish to prepare themselves more thoroughly than usual for important positions in the industries. Such men will ultimately become competent draftsmen, foremen of works, operators and stationary engineers, electrical workers, instrument men and surveyors, inspectors and leaders in the trades and industries.

Arrangements are provided whereby much of the work may be taken by correspondence. At the present time approximately one-half of the work may be taken in this manner.

Special emphasis is placed upon practical work and the student is given practice from the very beginning. The application of all the theory is carefully pointed out. The student is taught to use his learning.

These courses are open to those who are seventeen years of age or over, and who have had an eighth grade education, or its equivalent. High school graduates are not accepted.

The bulletin describing these courses will be ready in May. It will be sent to any one interested on request.

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THE IOWA ENGINEER

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EDITORIALS

In an interesting manner, Mr. R. H. Halpenny describes the more important feature of one of the largest transmission lines in service today. This line of 140,000 volts, the construction of which Mr. Halpenny was in charge, represents the latest practice in high tension transmission line construction. The bi-metallic cable of aluminum and steel is a novel feature indeed, and presented a new problem in heavy cable splicing.

Another difficulty encountered by the author was the varying character of the soil in which the towers were set. These must be secure against the most trying weather conditions, for their failure would mean imminent danger to life, besides the annoyance of interrupted service.

The air switch seems to have come into vogue with the use of such high voltages, thereby replacing the familiar oil switch. The operation of line switches by either electricity or air according to their location, is another up-to-date feature of the line.

——I. E.——

The contribution from Mr. R. A. Hart on the drainage of arid soils is highly instructive. Few people know that drainage is in any way associated with irrigation or arid lands, and yet Mr. Hart points out the fact that over two million acres of productive land is unfit for cultivation because it has become water-logged from irrigation or from lack of sufficient natural drainage. The excess water raises the level of the ground water nearer to the surface where it evaporates and leaves the alkaline salts on the surface of the ground. This kills most vegetation and the land often becomes barren. Proper drainage seems to be the only solution of the problem. Mr. Hart shows clearly how these drainage problems are treated. The solutions show the greatest difference between arid and humid drainage. Each case must be treated by itself and it involves the study of a dozen or more factors which seldom enter into the design of drains for humid soils.

——I. E.——

We desire to call special attention here to the new course in Structure Design which will be offered at Iowa State College this coming year. Mr. Allen Holmes Kimball, who is professor in charge, gives a general outline of the new course in this issue. For a long time the need of such a course of study has been felt and as now planned, the course will be very complete in most every detail. The new work will be an important enlargement of the scope of the engineering work of the college and will be welcomed by a large number of students.

——I. E.——

Everyone will admit that the old steam engine, harnessed tc the flour mill at Madrid, Iowa, merits the title of "An Old Timer." Yet to one permitted to watch the old veteran peacefully plodding away the fact that it has been in service for

sixty odd years seems incredible.

The notable features of this staunch old engine are: the rocker arm attachment for working water out of the cylinder, the cross-head shoes of hickory, the main shaft and like parts of cast iron, and in general its crude and massive construction.

In this connection is of interest to approximate the travels of the flywheel. Estimating that it has run 10 hours a day, 300 days in the year for 59 years, and during that time had a fly sat on one spot on the flywheel rim it would have travelled about four million miles, or 160 times around the earth.

Iowa Engineer Election

An election was held during April that resulted in the election of Arthnr Goldenstar, B. C. E., '15, as editor, and S. A. McGavren, B. C. E., '15, for business manager of volume fifteen of this magazine. These men are well fitted, both by their previous experience and faithful work on the staff, and their natural ability to conduct the affairs of this paper in a successful manner. It is with great pleasure and high recommendation that we intrnst to them the stewardship of the "Iowa Engineer" for the coming year.

Last But Not Least

As editor, this issue marks the close of onr efforts in connection with the "Iowa Engineer." We hereon release all claim to the title of Sir Knight of Pen and Typewriter. We rather feel that we have attempted mnch, yet accomplished little. However, our relations have been made pleasant ones, through the loyal support of our article contribntors, and the hearty interest of our readers, who have amiably endured our errors of omission and commission. For any improvements that have been effected in the policy of the paper, considerable credit is due the staff for their faithfnl co-operation. In closing we desire to thank whomsoever may have rendered us any service. For, howsoever small, it has been duly appreciated.

College Notes

The brick work is practically completed and the roof is now being placed on the new Chemistry Hall. The building will be finished by July 1st and ready for occupancy next fall. Every room in the building is well lighted by natural light, and an excellent system of ventilation is provided—certainly a pleasant place to work.

On April 30, Professor Evinger gave a talk on asphalt paving. The talk was illustrated by four reels of "movies," and was well received by a large audience. This is one of a series of educational films that have been shown to the students free of charge, and they have all been very popular.

The Mechanical Engineering Department has ordered a new Wordberg cross compound, condensing and non-condensing special experimental engine for the Steam and Gas laboratory. The cylinders which are 8"x13"x20" are steam jacketed. The high pressure cylinder will be fitted with poppet valve gear; low pressure with long range Corliss valve gear. The engine is

designed for 250 lbs. steam pressure and a superheat of 200 degrees Fahr. It is being built under contract and will be ready for use next fall.

On May 14 the following juniors were initiated into Tau Beta Pi, the honorary Engineering fraternity: R. L. Dickinson, H. O. Graham, E. L. Kaiser, Carl Sernstrom, V. W. Enslow, F. C. Schneider, S. A. McGavren, T. V. Houser, L. J. Fletcher, A. W. Clyde, A. W. Schulz.

·The committee of the American Society for Testing Materials, of which Dean Marston is chairman, has met and drawn up a set of specifications for tile. These specifications will be referred to the Society at the June meeting. A large number of new specimens has been received by the Experiment Station for breaking.

Work will soon be resumed on the 225 foot stack at the power plant. Numerous tests have been made both on the material that went into the stack and on actual samples of concrete as taken from the structure. The design has been checked over and found satisfactory. Work will be started again with the provision that the lower part of the stack may have to be bricked up to improve the appearance.

Mr. J. W. Eichinger has been placed in charge of the Highway Commission Service Bulletin, which is published monthly by the Commission. Mr. Eichinger has had experience as a newspaper man, and he is making the bulletin serviceable to the men interested in highway work in Iowa.

On May 13th the C. E.'s held an informal smoker, that was well attended. With a good supply of hydrocarbon available those present passed an enjoyable evening in games and song and talk.

Alumni Notes

C. H. Lee, C. E. '75, is a contracting engineer at Boise, Idaho.

C. F. Mount, C. E. '78, is a general contractor at Kappel, Pa.

Albert L. Hanson, C. E. '79, is following banking and farming at Ada, Minn., with politics as a side issue. He has been a member of the state senate for eight years.

Fremont Turner, M. E. '79, lives in Des Moines, Iowa, where he is in the contracting business.

Willis Whited, C. E. '79, who is engineer of bridges for the Pennsylvania State Highway Commission at Harrisburg, was on the campus recently.

Frank C. Colby, C. E. '81, is a consulting engineer and architect at Sioux City, Iowa.

C. D. Jackson, M. E. 85, is farming at Vergas, Minn., where he has been located for several years.

C. K. Munns, E. E. '93, has the controlling interest in an established mail order business in Detroit, Mich., after spending nearly twenty years in engineering work.

Chas. R. Cave, M. E. '95, is now located at Waverly, Iowa, his old home town.

Frank B. Spencer, E. E. '97, who is with the United States Equipment Co. of Chicago, was on the campus last month.

Emerson G. Reed, E. E. '97, is with the Westinghouse Co. at East Pittsburgh, Pa. He has charge of a section of the transformer engineering division.

W. H. Parsons, C. E. ex. '97, is now located at Santa Cruz, Calif., where he has a ranch. He is interested in mining as a side issue, having spent several years in the Alaska fields.

John C. Cleghorn, Min. E. '03, recently left Plamoth, Ore., for Grand Junction, Colo., where he has charge of the construction of fifteen miles of main canal for the Grand Valley Project, U. S. Reclamation Service.

Thos. F. Crocker, E. E. '03, is manager of the Beaver County Telephone Co., at Rochester, Penn.

F. A. Pielsticker, E. E. '04, is manager of the El Dorado Electric and Refrigerating Co. at El Dorado, Kan. He will be back on the campus for the '04 class reunion in June.

W. C. Botsford, E. E. '05, is located at Voltage, Ore.

Prof. T. R. Agg, E. E. '05, of the Department of Highway Engineering, has been asked to serve on the organization committee arranging for a northwestern road congress.

W. B. Warrington, C. E. ex. '05, who has been prominent in engineering work in Pocahontas county, Iowa, since he left college, died at Pocahontas February 11th.

L. L. Hidinger, C. E. '06, is vice-president and treasurer of the Morgan Engineering Co. of Memphis, Tenn. This company has charge of the engineering project for furnishing flood protection for Dayton, Ohio.

H. A. Lathrop, C. E. '06, is with the Southern Pacific Railway Company at Sacramento, Calif.

L. C. Schontz, E. E. '08, will take his degree in law from George Washington University June 1st. He will continue work in engineering and law in the practice of patent law.

Claude I. Grimm, C. E. '08, is engaged in structural engineering in the U. S. engineer's office at Wheeling, W. Va.

Charles Wagner, C. E. '08, and Miss Alice E. Slade of Des Moines were married February 24th. Mr. Wagner is engaged in engineering work in Des Moines, where they will make their home at 1725 Sixth avenue.

L. L. Leibrock, Min. E. '09, who has been at Buxton, Iowa, for several years, is now at Elkader, his old home town.

A. B. Reeves, C. E. '10, is with the U. S. Reclamation Service at Mitchell, Nebr.

J. E. O'Leary, C. E. '10, is contracting engineer for the Pittsburgh-Des Moines Steel Co. He is now in charge of their New York office which was recently opened.

J. J. Nicolay, M. E. '10, who has been with the Packard people at Detroit, Mich., for some time, recently visited on the campus. He has gone to Spokane, Wash., to visit relatives and expects to remain in the west.

Knowledge in the form of learning is inferior to knowledge in the form of discernment, because it is less effective. The former may be admired, but the latter is followed.—*Kerr.*

INDEX TO VOL. XIV.